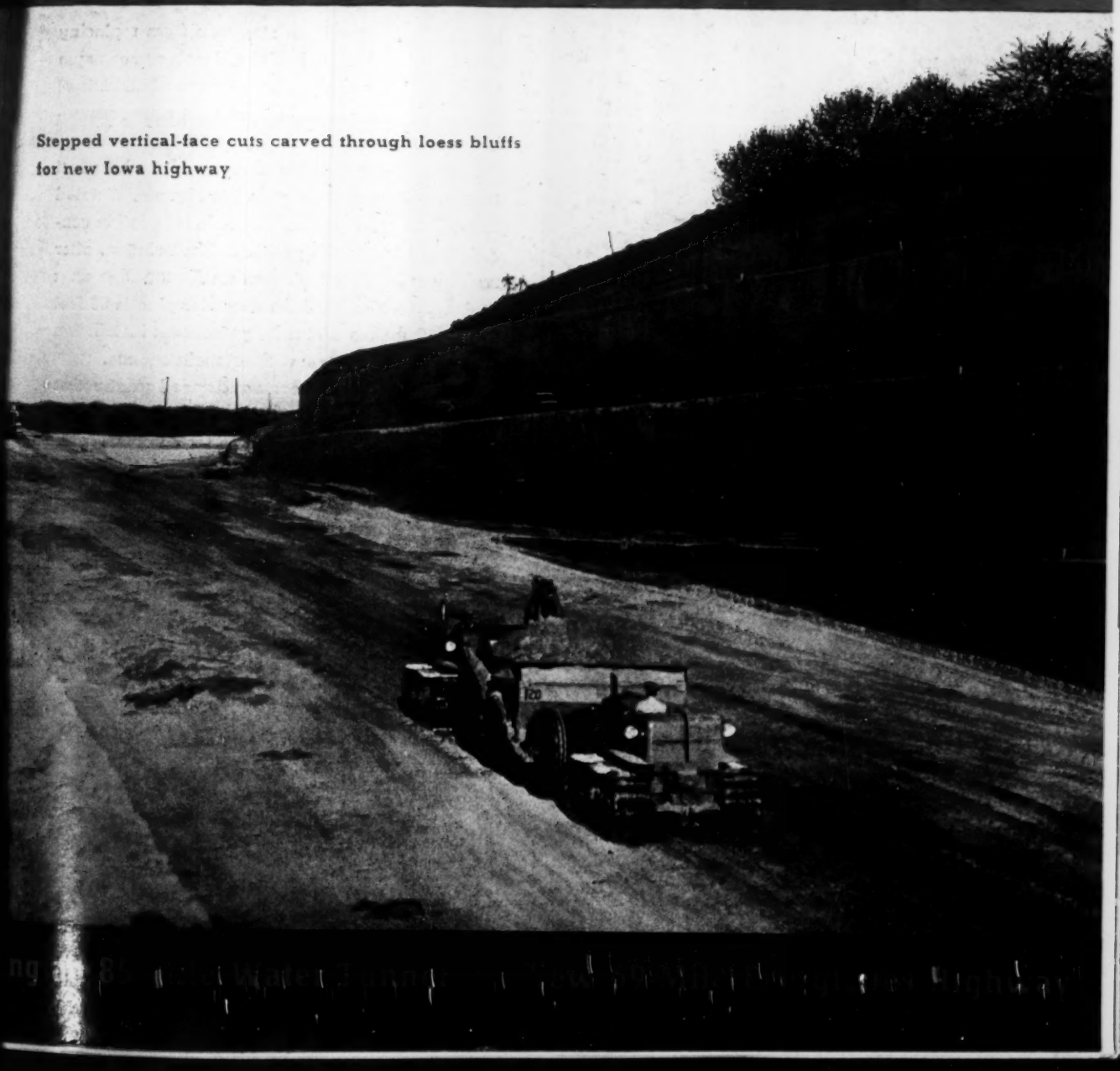
SEP 4 1940

# ENGINEERING NEWS-RECORD

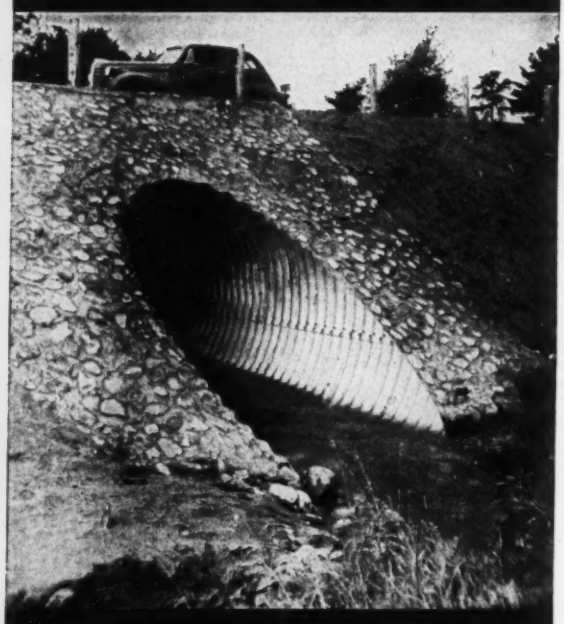
AUGUST 29, 1940



Stepped vertical-face cuts carved through loess bluffs for new Iowa highway

The increased weight and speed of modern vehicles made this structure obsolete. Maintenance was an expensive problem because the plank flooring had to be replaced at frequent intervals.

Placement of a timber mat for bearing surface and erection of the Multi Plate units was done in winter without difficulty. Local unskilled labor using only hand tools completed the job in three weeks.



The new structure is situated upstream from the old bridge site. Three feet of fill covers the pipe and the slope is protected against erosion by a rip-rap headwall. The pipe was beveled to fit the slope for better appearance and hydraulic efficiency.

# BRIDGE DOLLARS GO FARTHER

## when you use Multi Plate

**Limited funds need not stop you from replacing unsafe or inadequate bridges. Here's one example where the job was done with ARMCO Multi Plate at an estimated saving of 45 per cent over competitive material.**

**In this case relocation of the road, and the fact that the old structure was inadequate, dictated immediate construction. Unstable foundation conditions added to the problem. The solution, after making a bearing test, was an ARMCO Pipe on a timber mat. The 105-inch diameter pipe is 60 feet long and makes a sturdy, permanent installation that will last for years without maintenance.**

**You too can reduce costs and speed construction of large drainage openings by using ARMCO Multi Plate Pipe or Arches. Write us for complete information and prices. Armco Drainage Products Association, 501 Curtis Street, Middletown, Ohio.**

MULTI ARMCO PLATE

# ARMCO MULTI PLATE

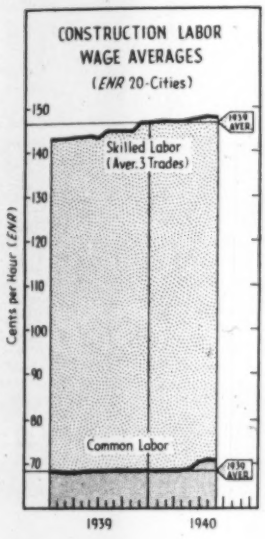
***A TYPE OF PRODUCT ORIGINATED AND DEVELOPED BY ARMCO ENGINEERS***

# CONSTRUCTION TRENDS

**Notes on significant movements in the construction industry**

## Activity on labor and material price fronts

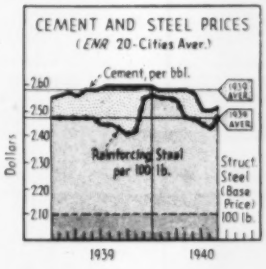
LABOR RATES in the construction field have increased moderately in the past three months after a fairly long period of stability. For nineteen months preceding May, 1940 the common labor *ENR* 20-cities' average rate moved within a ½c. range, never below 68c. per hour, nor rising above 68½c.



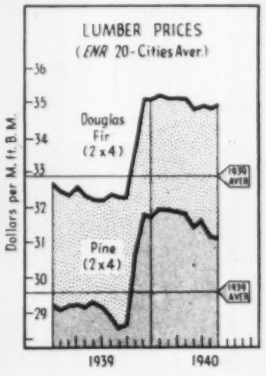

In May the common labor average rate rose to 69c., in June to 70.3c., and in July to 70.7c., the rate which prevails for August. The current month's hourly wage average is 3½ per cent above the annual average for 1939, 4 per cent higher than the 1938 average, and a new all-time high for common labor.

The skilled labor rate average for August, $1.476 per hour, increased 0.8 per cent over the wage at the opening of the year, and was 2 per cent above the record annual average for 1939. The three crafts used in computing the skilled average all climbed from their levels at the opening of the year. Bricklayers' rate rose 0.3 per cent; carpenters', 1.3 per cent; and structural ironworkers', 1.1 per cent. All three of these classifications of skilled labor are establishing new records with each increase.

CONSTRUCTION material price trends are mixed. August cement average for the *ENR* 20-cities, $2.52 per barrel, is quoted 3 per cent under the 1939 average price; structural steel, at $2.10 per 100 pounds, is unchanged from a year ago; reinforcing steel, $2.49 per 100 pounds, up 0.6 per cent; and Fir and Pine lumber, currently averaging $34.97 and $31.12 per M feet, are reported 6 and 5 per cent higher than their respective 1939 averages.




Cement and structural steel prices remained stable throughout the period following the start of the European conflict. Cement, however, dropped from $2.59 in April to $2.51 in June as a result of reductions in California.




Immediately after the outbreak of war in Europe last year, reinforcing steel prices rose 6 per cent, climbing from $2.41 before the war to $2.57 in December.

Pine lumber prices jumped 11 per cent and Fir was up 8.6 per cent within two months after war was declared last September. At the present time lumber prices are below November quotations.

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The Week In Engineering and Construction

ENGINEERING NEWS-RECORD • AUGUST 29, 1940

# Army begins work of housing increased forces

## Congress delays, so Army gets an allotment from President's "blank check" fund to start its huge task of barracks construction

Without even waiting for Congress to appropriate and legislate, the Army this week tackled the task of providing housing for the 400,000 conscripts and national guardsmen who will be called out by January 1.

The War Department initiated a program for the construction of cantonments in cold weather climates, and the establishment of tent camps in warm climates —all on a scale unprecedented since World War days. The program calls for erection of temporary housing or tentage for 319,210 troops at 34 posts throughout the country.

Construction work involved in this program will be the erection of two-story wooden houses for use as barracks, and installation of necessary utilities and hospital facilities.

### First allotments $29,000,000

To finance this work until funds can be appropriated by Congress, President Roosevelt allocated $29,000,000 from his $200,000,000 "blank check" fund. The Presidential allocation was absolutely needed because the Army is estopped from even requesting this money until national guard and selective draft legislation is enacted.

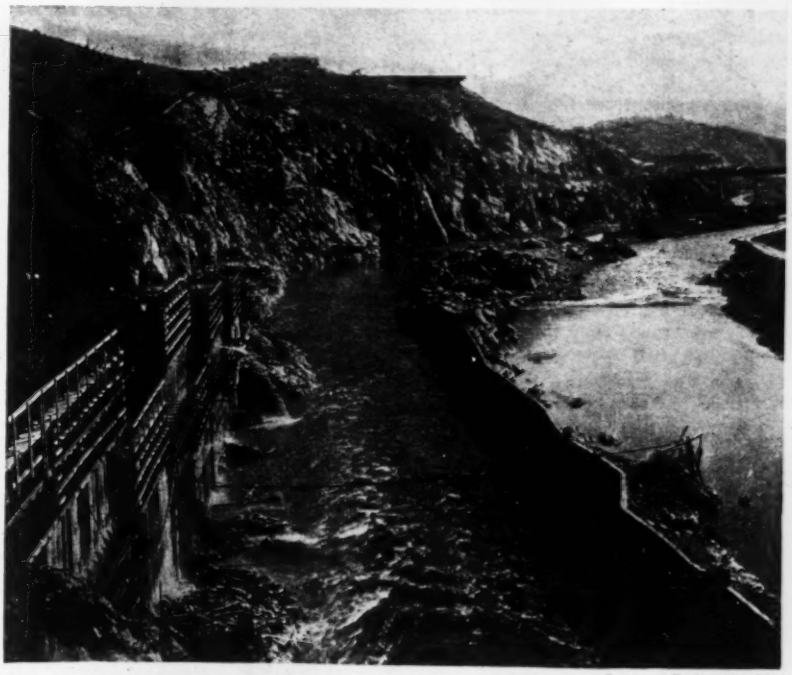
The $29,000,000 allocated will only permit a start on the over-all program which will require construction of housing for an estimated 1,000,000 men at a cost roughly fixed at from $60,000,000 to $70,000,000.

### Several large contracts awarded

Release of the Presdential money was followed by the award of more than $4,000,000 of contracts for temporary housing at two of the posts. Williams Lumber Co., of Columbus, Ga., was awarded a $2,079,790 contract to erect temporary buildings at Fort Benning, where quarters for 16,000 men, composing an entire armored division, must be provided under the program. A $2,731,000 contract for temporary housing at Camp Ord, where 10,000 troops of the 7th Division and miscellaneous units will be quartered, was awarded to Ford J. Twaits-Morris-Knudsen, Inc., Los Angeles. The Camp Ord contract calls for erection of some 600 buildings.

### Work begun at a few posts

Previously, other monies had been used to award large contracts of $1,159,000 and $2,193,000 for housing at Fort Knox and Camp Jackson, S. C., respectively (*ENR* August 22, 1940, p. 7), and for smaller projects at Fort Benning, Arlington, Va., and Stockton Airport, Calif.



*Bureau of Reclamation Photo*

## Diversion of Sacramento River begun at Shasta Dam

*To prepare bedrock for the middle section of Shasta Dam, the Sacramento River was diverted into the channel at the left Aug. 14. The temporary passageway, which is 50 ft. wide and 2,000 ft. long, will carry the flow of the stream until high water arrives next winter, when the river will be allowed to flow again in its natural course. By that time concrete will have been placed for the foundation of the dam.*

*Shasta Dam, which will be 560 ft. high, is being built by the Bureau of Reclamation for navigation, irrigation, flood control and power. It is the major project of the Central Valley work in California.*

*The first bucket of concrete was placed in Shasta Dam on July 8, and since then work has proceeded at a fast pace. The concreting operations are of unusual interest by virtue of the cableway layout which consists of a single huge head tower from which radiate seven separate cableway spans.*

## Large timber joints may be tested

Consideration is now being given to the possibility of making tests to destruction on timber joints and perhaps on complete timber arches used in the buildings of the Golden Gate International Exposition at San Francisco, which are soon to be demolished. A committee of the San Francisco section, Am.Soc.C.E., which has been studying the matter, included in its report the following:

"We conclude that much useful information of benefit to the engineering profession, to the construction industry and to the public could be obtained from a comprehensive test program. The following list of tests, with approximate cost, is considered desirable, the sequence indicating the order of desirability:

| | | |
|---|---|---|
| 1. About 50 individual timber joints to be removed from the structures | $1,000 | |
| 2. Lateral load resisting abilities of piles, footings and soil | 500 | |
| 3. Small trusses and trussed rafters | 2,500 | |
| 4. Diaphragms consisting of plywood, diagonal sheathing, plaster and plaster board | 2,500 | |
| 5. Compression and tension members and beams consisting of built-up and solid members | 1,000 | |
| 6. Full size arches or large trusses | 2,500 | — 5,000 |
| 7. Vibration tests | 500 | |
| Total | $10,500 | $13,000 |

Cost estimates are based on the assumption that the items to be tested would be furnished free by the exposition, that testing equipment at the state university could be used without charge and that some student aid could be arranged. To the items listed would have to be added the cost of an engineer and an assistant to plan and direct the tests and to write a report. Altogether, $5,000 to $20,000 could profitably be spent on this program, the committee reports, the smaller sum including only the first three items of the program recommended above.

• • •

## Golden Gate Bridge makes a profit

A net profit of $17,765 from operation of the Golden Gate Bridge at San Francisco for the fiscal year ending June 30, 1940 was announced at the directors' meeting on August 14. This is the first profitable year for this structure; the loss last year was $135,003. Unlike the San Francisco Bay Bridge, tolls on the Golden Gate Bridge have not been decreased and in fact the truck rates have been increased with material effect on net returns.

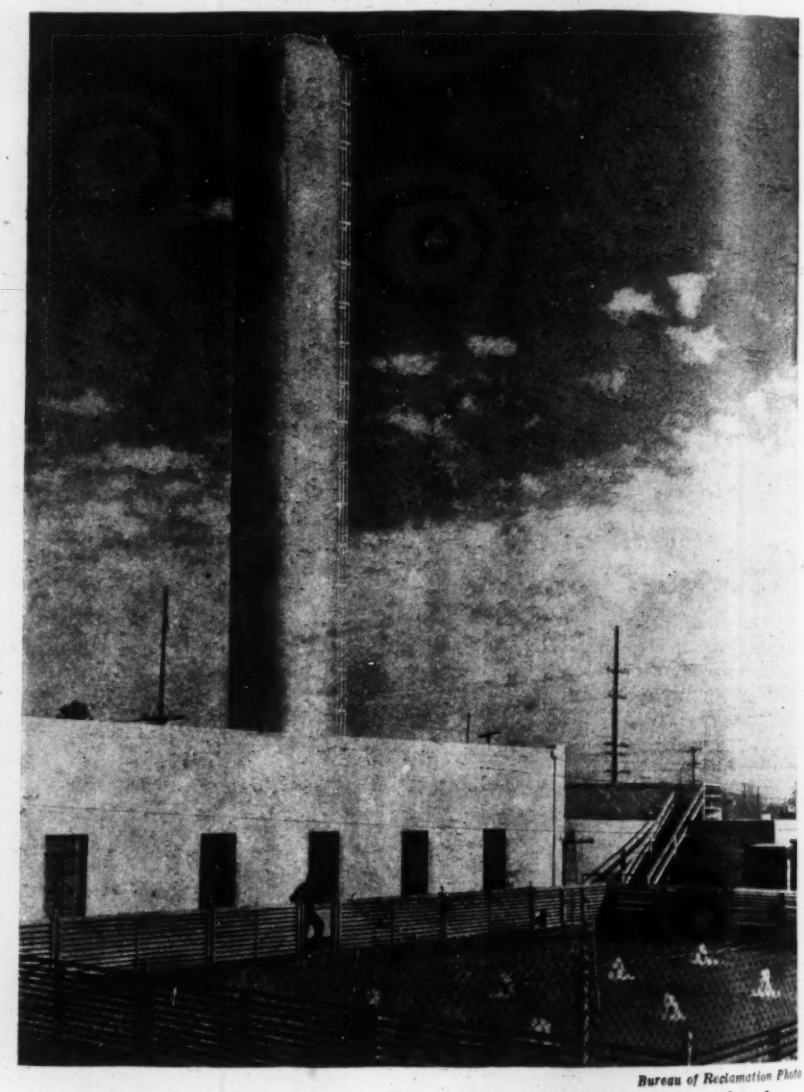
The total number of vehicle crossings in each of the three years the bridge has been in service are:

| | | |
|---|---|---|
| Year ending | June 1938 | 3,311,512 |
| " " | June 1939 | 4,031,504 |
| " " | June 1940 | 4,315,867 |

The year's operating costs were reported as $2,039,687 of which $1,519,000 went to pay interest on the $35,000,000 worth of bonds.

## Philadelphia building probe reveals little

Following a three-and-one-half month probe of activities of the Building Trades Council, A.F.L. unions, and allied builders' groups, the federal investigation of the building industry in Philadelphia has ended with "a clean bill of health" for the industry in that area. Begun to investigate an alleged builder-union monopoly, to restrain low-cost construction of homes, no collusion or restraint of trade was found.



Bureau of Reclamation Photo

## First city gets water from Central Valley project

*Last week when the partly complete Contra Costa Canal began supplying water for the city of Pittsburg, Cal., the first unit of the Central Valley project of California went into operation. Shown is the water bubbling up in the aerating basin in the Pittsburg municipal waterworks, which supplies about 700,000 gal. per day for the city's 12,000 population. The new supply replaces an old supply from deep wells adversely affected by salt water percolation from nearby bays.*

*Furnishing water for the city of Pittsburg is but one of the many objectives of the $220,000,000 Central Valley project, which is also for navigation, flood control, supplemental irrigation, salinity control, industrial water service, recreational development and generation of electric power.*

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# Conference committee completes work on highway bill

### Now carries amendment relative to national defense roads which may alter time-honored federal-state set-up

The regular biennial federal-aid highway bill, which has finally been reported out of a Senate-House conference committee, carries an amendment regarding defense roads projects, that some experts say significantly changes federal-state relationships under the Public Roads Administration program.

The amendment provides that in approving federal-aid highway projects to be carried out with any unobligated funds apportioned to any state, "the commissioner of public roads may give priority of approval to, and expedite the construction of, projects that are recommended by the appropriate federal defense agency as important to the national defense."

As the amendment was slipped into the bill during Senate debate, it said that the commissioner "shall"—instead of "may"—give priority to defense projects. However, even with the mandatory language of the original toned down in the conference committee, state highway officials assert that the provision is a radical departure from the time-honored practice by which the states initiate projects.

The amendment gives the PRA commissioner authority to initiate a project which the Army or Navy has designated as having defense value, and to "expedite the construction of" such projects through use of unobligated funds apportioned to any state, according to the interpretation of spokesmen for the state commissions.

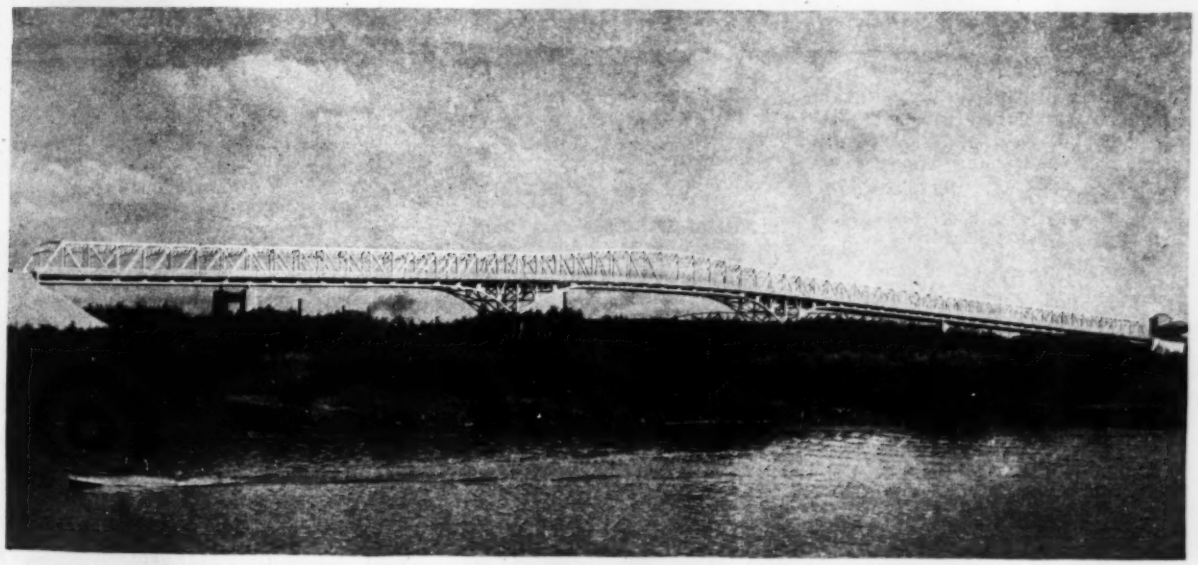
As an example of the trouble that might arise over this, a Missouri case is cited. There, the War Department wanted to widen and improve a country road leading from St. Louis to the airport. Therefore, it approached the state highway department and asked that the roadway be included in the state highway system, so that a portion of the state's federal-aid highway apportionment could be used on the $800,000 project.

The state highway department refused the request, asserting that St. Louis had already received more than its fair share of the state's federal-aid funds. The suggestion was made that the federal government should stand the cost of the entire project.

State highway officials assert that the new defense amendment to the law will permit the PRA commissioner to bring pressure on the state to use its portion of federal-aid funds for such purposes. They also point out that the annual authorization of $163,500,000 carried in the bill is $27,500,000 less than authorized annually during the current biennium, and that the states will therefore have less money to devote to defense projects in 1941 and 1942, the years covered in the bill.

On the other hand, Federal Works Agency officials deny that the amendment has any such radical intention as represented by state officials. They say that the power is necessary to take care of defense projects, and point out that the exercise of it is optional, not mandatory.

Another section authorizes the Recon-



## Four-lane bridge relieves traffic congestion at Lorain, Ohio

*First to be completed of the two new bridges being built over the Black River at Lorain, Ohio, is the 1700-ft. continuous truss bridge shown above. It provides four lanes of traffic, two each way on a 42-ft. undivided roadway and eliminates considerable congestion of local traffic.*

*Superstructure of the bridge consists of a 200-ft. span, two spans of 250 ft., two at 300 ft., and a central span of 400 ft. with a 97-ft. clearance over the river channel to permit passage of lake ore boats to docks and smelters.*

*Hard shale provides a good foundation near the ground surface on one side of the river, but on the other side pipe piles 50 ft. long and 12 in. diameter, driven to refusal and then filled with concrete, were necessary. These provide a bearing load of 90 tons each. Concrete piers with a maximum height of about 70 ft. support the superstructure.*

*Falsework was used to support the side spans during construction, but the center span was erected as a cantilever of the continuous trusses.*

*The bridge design and its construction were supervised by R. L. Harding of Wilbur Watson and Associates, Cleveland. The consulting architect was F. R. Walker, also of Cleveland. The Great Lakes Dredge & Dock Co. built the substructure, and the American Bridge Co. erected the superstructure, including steel grid flooring filled flush with concrete. Harry L. Dunham is engineer for Lorain County, the owner.*

*The work was financed by a county bond issue and a 45 per cent PWA grant.*

struction Finance Corporation to make loans to states for the purchase of rights-of-way for essential federal-aid projects. However, the conferees struck out a House provision which would have permitted the states to put up their federal aid apportionments as additional security for such loans. Senate conferees objected to "placing a mortgage on federal-aid funds."

**How money is apportioned**

The $163,500,000 authorized annually is provided under the following categories: for regular federal aid, $100,000,000; secondary roads, $17,500,000; grade crossings, $20,000,000; forest roads, $10,000,000; public land roads, $1,500,000; park roads, $4,000,000; parkways, $7,500,000, and Indian reservation roads, $3,000,000.

The measure does not alter the present 50-50 federal-state matching arrangement, nor does it increase federal aid even on projects of national defense value.

• • •

## Military roads would cost $24,000,000 in Ohio

In response to a request from the federal government, the Ohio State Highway Department has prepared plans showing that estimated cost for reconstruction, widening of roadways, pavement and bridges, and stabilizing of shoulders of Ohio roads needed for military purposes would cost $24,000,000 to make them meet with the specifications recommended.

This amount is in addition to the $23,000,000 now being spent for projects under construction and in the program approved and contemplated under the normal highway construction procedure during the ensuing five years. The estimate is for work outside municipalities and does not include any right-of-way costs.

• • •

## Pennsylvania road work reaches 10-year peak

With $50,000,000 in contracts scheduled to be awarded by the end of this year, the Pennsylvania State Highway Department reports that construction work in Pennsylvania has reached its highest peak since 1930. According to I. Lamont Hughes, secretary of highways, $32,000,000 of road projects have been awarded to date, and construction is steadily growing by the award of additional contracts at the rate of ten to fifteen per week.

Until this year the highest point in Pennsylvania road construction since 1930 was in 1936 when $28,349,000 was expended.

# BRIEF NEWS

MORE than 1,000 less men are employed by the Kentucky State Highway Department at this time than a year ago with a corresponding payroll reduction of $53,000 a month.

EAST ST. LOUIS & Interurban Water Co., which supplies water to East St. Louis, Scott Field and other municipalities in the vicinity of East St. Louis, is installing floodlights at its purification plant and pumping stations to make it easier for watchmen to prevent sabotage.

A GROUP INSURANCE policy has been sold to the 2,100 employees of the Mississippi State Highway Department by the Equitable Life. The department and employees will share the cost of the policy, which totals $7,500,000.

SIGNS MARKING the entrance to the Charleston, S. C. municipal waterworks at Hanrahan on U.S. Route 52 have been removed by the South Carolina State Highway Department as a precaution against possible sabotage at the plant.

# JOBS OF THE WEEK

***JETTY, Westport, Wash.***

Columbia Construction Co., Westport, Wash. was low bidder for reconstructing the Grays Harbor North Jetty with a bid of $1,720,354. The Seattle office of the U. S. Engineers took bids for the work Aug. 20.

***WARPLANE FACTORY, Dallas, Texas***

Austin Company, Cleveland, O. was awarded the contract for constructing for the North America Aviation Co., Inglewood, Calif., an airplane factory to manufacture trainers, fighters and bombers. Cost of the plant, which will be built on a 140-acre site on Jefferson Blvd. adjacent to Hensley (army) Field, will be $7,000,000 with equipment. The plant will have about 1,000,000 sq.ft. of floor space and two 6,000-ft. runways.

***SEWAGE TREATMENT PLANT, Cranston, R. I.***

Bass Engineering & Construction Co., Detroit, Mich., with a bid of $657,995 was low bidder for constructing a sewage treatment plant for the city of Cranston. Everett Higson, chairman of the sewer commission, City Hall, is in charge of the work for which Fay Spofford & Thorndike, Boston, Mass., are consulting engineers.

***BUILDINGS, Fort Benning, Ga.***

Williams Lumber Co., Columbus, Ga. was awarded a $2,079,790 contract by the Constructing Quartermaster for constructing temporary buildings at Second Armored Division, Fort Benning. The contract specifies that work will begin in ten days and be completed in ninety.

***BUILDINGS, Camp Ord, Calif.***

F. J. Twaits Co., Los Angeles, and Morrison-Knudsen Co., Los Angeles, with a contract of $2,731,000, will construct temporary housing facilities, 12 administration buildings, 177 barracks, blacksmith shops, guard houses, and a hospital. The Constructing Quartermaster, Presidio of Monterey, the owner, took bids Aug. 15.

***WAREHOUSE, Philadelphia, Pa.***

Wark & Co., Philadelphia, Pa., will construct a warehouse at the Philadelphia quartermaster depot under provisions of a $700,000 contract. The Constructing Quartermaster, Washington, D. C., awarded the contract.

***EXCAVATING FOR DUCHESNE TUNNEL, Utah***

Utah Construction Co., Ogden, Utah, was low bidder with a bid of $727,575 for excavating from Station 163.35 to Station 32.75 for the Duchesne Tunnel of the Provo River Project when the Bureau of Reclamation, Provo, took bids Aug. 21.

***FLOOD-CONTROL CONDUIT, Hartford, Conn.***

B. Perini & Sons, Inc., Framingham, Mass., was awarded a $2,877,784 contract for constructing a 5,700-ft. reinforced concrete conduit to carry the flow of the Park River from Bushnell Park to the Connecticut River. Estimated cost of the work, which is being done by the U. S. Engineers, Providence, R. I., is $4,000,000.

***SCHOOLS, New York, N. Y.***

Psaty & Fuhrman, Inc., New York, bid low for the Woodrow Wilson and the Benj. Franklin high schools, both in New York, with a bid of $1,296,000 and $1,861,000, respectively, when bids were opened Aug. 22 by the superintendent of school buildings, New York Board of Education. Although, because contractors demanded war protection, no bids were received in June for these two projects, six bids free of protection clauses were submitted on the Benjamin Franklin School and seven on the Woodrow Wilson School when the opening was held this week.

NOTE—Additional bidding and contract news on over 600 projects, large and small, appear in the Construction News Section beginning on page 89.

# Palmer outlines housing plan for defense workers

***Would authorize $150,000,000 for work, which would be supervised by Public Buildings Administration***

The knotty problem of how to provide housing for workers engaged in defense industry and activities seems a step nearer solution following submission of a $150,000,000 defense housing proposal to Congress this week by Defense Housing Coordinator C. F. Palmer.

In a letter to Speaker Bankhead, Palmer enclosed a draft of a proposed bill authorizing expenditure of $150,000,000 for the purpose, and placing defense housing under the Federal Works Administrator and the Public Buildings Administrator.

Under the bill, the Administrator is empowered to acquire land for the program through purchase, gift, or condemnation. Money derived from rentals would be returned to the appropriation.

Importance of Palmer's plan lies not so much in its details as in the fact that it would cut the United States Housing Authority out of the defense housing field. Because USHA and Congress have long been deadlocked over the housing issue, the Palmer plan appeals to the USHA opposition in the House and promises to receive substantial backing there.

USHA's legislative troubles, which started more than a year ago with a request for an additional $800,000,000 authorization for low-rent housing, recently have spawned a confusing number of substitute housing bills. When the House rejected the $800,000,000 bill, the sum was cut to $150,000,000; but still the House refused to act.

With advent of the defense program, various attempts have been made to place USHA in charge of defense housing construction; an appropriation of $100,000,000 is proposed for this purpose in an amendment to be offered to the $5,000,000,000 deficiency defense bill by Senator Wagner, of New York, when it is taken up in the Senate soon. Palmer's proposal is expected to reduce the chances of Wagner's amendment materially.

Another phase of the Palmer plan, which is slated for announcement as soon as details are worked out, involves use of Reconstruction Finance Corp. funds to enable defense workers to buy homes under the FHA home purchase plan, without making the usual 10 per cent down payment.

RFC will set up a corporation to lend equity money for the down payment, and the defense worker thus will be able to borrow 100 per cent on his home, instead of the present 90 per cent, and pay it back in monthly installments.

This plan will be applied in communities where the defense program has prospects of permanency, whereas, the Public Buildings Administration will confine its program of constructing rental projects to communities where defense activity promises to be only temporary.

As the defense housing coordinator submitted his recommendation to Congress, he was busy strengthening his own staff and his own position in the government housing field. His office announced the appointment of four housing consultants—all of them leaders in the housing field.

The foursome are: S. M. Buckingham, manager of the Cleveland Terminals Building Co. and representative of the National Association of Building Owners and Managers; M. L. Colean, research director of the housing survey for the 20th Century Fund; Herbert U. Nelson, executive vice president of the National Association of Real Estate Boards, and Coleman Woodbury, director of the National Association of Housing Officials.

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## Aircraft firms get additional RFC loans

***Included is $51,000,000 to Curtiss-Wright, $10,500,000 to Boeing and $17,000,000 to Bendix***

Jesse H. Jones, federal loan administrator, has agreed to a plan for the Reconstruction Finance Corp. to make additional loans of $78,500,000 for increased aircraft production. This is in addition to the $92,000,000 loan recently made to the Wright Aeronautical Corp. for increasing engine production.

Of the new loans $51,000,000 is to the Curtiss-Wright Co., $10,500,000 to Boeing Aircraft Co., and $17,000,000 to Bendix Aviation Corp. As a result Curtiss-Wright plans to expand its Buffalo plant and build new plants at Buffalo and St. Louis, and in Ohio. Boeing will spend $7,000,000 to $8,000,000 for expansion at Seattle and $2,500,000 to $3,000,000 for a new plant at Wichita, Kan. Bendix has not announced where its plants will be built.

The War Department has proposed that the new plants required for aircraft production be paid for by the federal government in five equal annual payments. The plan, which has been approved by the acting controller general, calls for eventual assumption of title to the factories by the government. Despite this fact it is contemplated that the five-year amortization schedule, contained in the excess profits tax bill now before Congress, will apply to the plants.

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## Road repair board named in North Carolina

Frank Dunlap, chairman of the North Carolina State Highway and Public Works Commission, W. Vance Baise, chief state highway engineer for the road commission, and W. L. Craven, the commission's bridge engineer, have been named members of the special committee to have "full powers" in rushing reconstruction and repair to North Carolina highways and bridges damaged by recent floods. The three men were appointed after Gov. Hoey had assured the commission that he would allocate up to $3,000,000 from the state's surplus fund to repair damage to the state's road system.

No definite estimate has been made of the total flood damage for the state, but it is considered to be far in excess of that due to ice and snow during the winter of 1939, when $2,332,000 of damage resulted.

Baise states that at least $2,000,000 will be required to make the roads "serviceable."

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## Five-ton highway bridge stolen in Illinois

Last week a new duty for Charles Sherertz, highway engineer for Williamson County, Ill., was recovering a 5-ton steel highway bridge which had been stolen from beside a small stream at the edge of Marion, Ill. Sherertz found the bridge in a junk yard in St. Louis, where the thieves sold one section, which they had delivered with a tractor on July 15, for $38.70, and two weeks later a second section for $54.95.

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## Hydraulic Institute offers pump essay awards

To stimulate the interest of younger men in the problems of the pump industry, the Hydraulic Institute is sponsoring a contest with prize awards of $100, $50, and $25 for essays of material benefit to the pump industry. The papers, which must be received before Sept. 30, may be written by any employee on the payroll of any member of the Hydraulic Institute, excluding executives or heads of departments or those holding managerial or policy-making positions.

C. C. Rohrbach, 90 West St., New York City, is secretary of the Hydraulic Institute.

## OBITUARY

FRANCIS F. MAXWELL, 69, for many years assistant civil engineer for the Pennsylvania R. R., died at his home in Jacksonville, Fla., last week. Maxwell recently had been connected with the Florida State Road Department.

MILTON FRESHWATER, 62, retired paving contractor and president of the old Freshwater Construction Co., which he established in 1909, died Aug. 15 in Broadview Heights, Ohio.

ALEXANDER R. TAYLOR, 68, member of the Taylor & Baldwin Co., and a former state highway director of Ohio, died Aug. 19 in Detroit. Taylor went to Columbus in 1919 to organize the Taylor & Baldwin firm, which specializes in building materials. Previous to that he served as county engineer for Hardin and Hancock counties, Ohio.

STERLING C. LINES, 67, consulting engineer who served as a member of one of the investigating committees after the St. Francis Dam failure in 1928, died Aug. 19.

FRANCIS L. MILLER, 70, who retired four years ago after service with the Pennsylvania R. R. as a civil engineer, died Aug. 20 in Los Angeles, where he had been making his home since his retirement.

A. B. DEKAY, contractor of Helena, Mont., and member of the firm of Hugenin & DeKay, architects of Helena and Butte, Mont., died recently. He had been active in the architectural and contracting field in Helena for the past 25 years.

H. C. NEUFFER, 49, partner with W. R. Holway in the engineering firm of Holway & Neuffer with offices at Tulsa, Okla. and Albuquerque, N. M., died in Albuquerque Aug. 23. Neuffer, who was connected with the Indian Service and private irrigation projects in the southwest for many years, was designing engineer for the Coolidge Dam and for six years was supervising engineer for the Indian Service at Albuquerque.

J. ARNOLD NORCROSS, 70, consulting engineer in the construction and operation of illuminating gas plants, died Aug. 19 at Dover-Foxcroft, Me. Following graduation from Stevens Institute of Technology in 1891, he worked with the Consolidated Gas Co., New York. He became superintendent of construction for the War Department in 1893 and later directed construction of the gas works for the West Point Military Academy.

EDWARD THORNTON, 53, assistant engineer of the city department of water supply of New York City, died in that city Aug. 20. Following his civil engineering education at the University of Virginia, he worked as construction engineer on the Panama Canal.

C. C. COTTRELL, 57, manager public relations department of the California State Automobile Association, died Aug. 22. Cottrell, a graduate of the University of Nebraska, for some years was state highway engineer of Nevada.

JAMES C. PENTECOST, 65, former superintendent of construction of bridges and buildings for the Frisco R. R. and since then a building contractor, died Aug. 14 in Cotter, Ark., while on his vacation.

GEORGE F. BLACKIE, 70, retired chief engineer of the Nashville, Chattanooga & St. Louis R. R., died in Nashville, Tenn., last week.

WILLIAM L. HANCOCK, 69, retired consulting engineer for the federal government, died last week at Atlanta, Ga. In 1913 he was employed as southeastern engineer for the T. L. Smith Co., Milwaukee, and was later connected with Pratt Engineering Co.

JOSEPH L. SHEPLEY, 55, president of Fielding & Shepley, Inc., highway and engineering contractors of St. Paul, died recently in that city.

## CONTRACTS AND CAPITAL

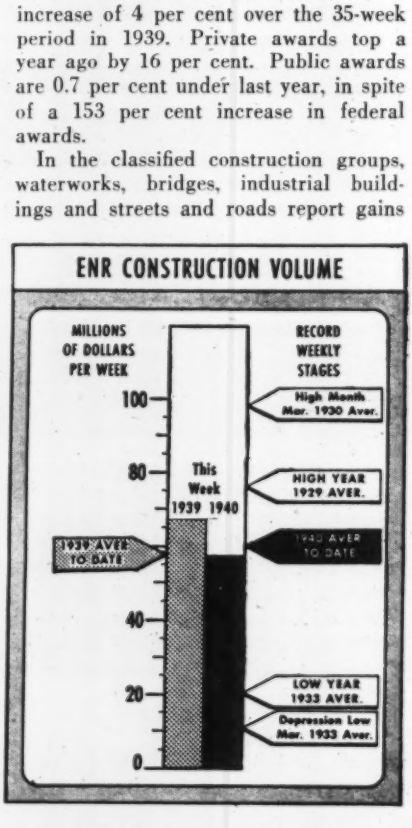
ENGINEERING CONSTRUCTION awards for the week total $57,444,000, a drop of 55 per cent from the near-record volume of a week ago, and 14 per cent below the total for the corresponding 1939 week.

Private construction is up 7 per cent compared with a week ago, but is 16 per cent below the total for the 1939 week. Public awards are 66 and 13 per cent lower, respectively, than last week and last year.

The current week's volume brings 1940 construction to $2,134,721,000, an increase of 4 per cent over the 35-week period in 1939. Private awards top a year ago by 16 per cent. Public awards are 0.7 per cent under last year, in spite of a 153 per cent increase in federal awards.

In the classified construction groups, waterworks, bridges, industrial buildings and streets and roads report gains over a year ago. Comparisons with the corresponding 1939 week reveal increases in waterworks, sewerage, and industrial buildings.

New capital for construction purposes for the week totals $16,406,000, an increase of 34 per cent over the volume for a year ago. The current week's financing is made up of $9,676,000 in state and municipal bonds, and $6,730,000 in corporate security issues.




### CONTRACTS

(Thousands of dollars)

| | Week Ending Aug. 31 1939 | Aug. 22 1940 | Aug. 29 1940 |
|---|---|---|---|
| Federal | $12,990 | $79,836 | $8,452 |
| State & Municipal | 29,791 | 29,599 | 28,674 |
| Total public | $42,781 | $109,435 | $37,126 |
| Total private | 24,228 | 19,014 | 20,318 |
| TOTALS | $67,009 | $128,449 | $57,444 |
| Cumulative 1940 | (35 weeks) | | $2,134,721 |
| 1939 | (35 weeks) | | $2,055,915 |

Note: Minimum size projects included are: Waterworks and waterways projects, $15,000; other public works, $25,000; industrial building, $40,000; other buildings, $150,000.

### NEW PRODUCTIVE CAPITAL

| | Cumulative 1939 35 Wks. | 1940 35 Wks. |
|---|---|---|
| NON-FEDERAL | $1,021,712 | $1,176,759* |
| Corp. Securities | 173,578 | 158,280* |
| State & Mun. | 403,982 | 599,819 |
| R.E.A. loans | 89,445 | ..... |
| U.S.H.A. loans | 160,852 | 118,501 |
| R.F.C. loans | 3,855 | 116,139 |
| Fed. Air-Hwy. | 190,000 | 184,000 |
| FEDERAL | $1,128,028 | $808,572 |
| TOTAL CAPITAL | $2,149,740 | $1,985,331* |

* Revised.

### FHA MORTGAGES

| | Week Ending Aug. 26 1939 | Aug. 17 1940 | Aug. 24 1940 |
|---|---|---|---|
| Selected for appraisal | $21,798 | $28,471 | $28,429† |
| Cumulative 1940 | (34 weeks) | | $848,415† |
| 1939 | (34 weeks) | | $766,479 |

† Subject to revision.

### ENR INDEX NUMBERS

| Index Base = 100 | | 1913 | 1926 |
|---|---|---|---|
| Construction Cost | Aug. '40 | 242.18 | 116.42 |
| Building Cost | Aug. '40 | 201.71 | 109.04 |
| Volume | July, '40 | 308 | 135 |

# Senate adds $15,000,000 construction to supplemental defense bill

***Additions include $11,065,000 for Navy public works, and $3,000,000 for facilities at military posts***

The Senate appropriations committee added a total of $20,000,000 of construction items to the House-approved $5,000,000,000 supplemental defense appropriation bill in reporting it to the Senate early last week.

The largest addition was: $11,065,000 for navy public works construction. Also added was a $3,000,000 appropriation and a $2,000,000 authorization for constructing facilities at military posts to store aviation gasoline.

The public works increases approved by the Senate included an item of $1,750,000 for repairs and replacements at Parris Island, S. C., made necessary by the hurricane of August 12.

Other public works projects added to the bill were:

Navy Yard, Charleston, S. C., miscellaneous shipbuilding facilities, $465,000;

Destroyer base, San Diego, Calif., temporary storehouses, $500,000;

Naval Academy, Annapolis, Md., additional facilities, $1,985,000;

Naval training station, Great Lakes, Ill., improvement of power plants, $450,000; improvement of sewage disposal plant, $125,000; and temporary construction and facilities for additional enlisted personnel, $1,750,000;

Naval training station, Newport, R. I., temporary construction and facilities for additional enlisted personnel, $800,000;

Naval training station, Norfolk, Va., temporary construction and facilities for additional enlisted personnel, $1,950,000;

Naval training station, San Diego, Calif., additional facilities, $1,250,000;

Naval ammunition depot, Charleston, S. C., ammunition storage facilities, $1,500,000;

Naval torpedo station, Newport, R. I., extension of administration building, $200,000; extension of barracks for school for torpedo men, $150,000;

Marine Barracks, Parris Island, additional construction for increase in Marine Corps personnel, $2,000,000.

Receiving barracks for crews of ships going into commission at various locations, $2,200,000; and

Storage for aviation gasoline at various locations, $2,500,000.

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## Surveying conference well attended

***Thirty papers presented as more than 60 men representing 31 colleges meet.***

When the second national surveying teachers' conference opened July 30 at the summer surveying camp of the Case School of Applied Science near Loudonville, Ohio, some sixty-odd men representing 31 colleges, 5 business organizations and 5 government departments, were on hand. Present were heads of the departments of civil engineering, teachers of surveying, men responsible for the execution of government surveys, manufacturers of surveying instruments, and practicing engineers. Also present were 35 members of their families.

During the seven working days of the conference, the first such meeting to be held since that at Rainy Lake in northern Minnesota three years ago, some 30 papers and prepared talks were presented. Subjects discussed included surveying practice, the principles and technique of teaching surveying, and design and use of surveying instruments.

Following the committee reports the conference adopted proposals calling for a recommended "minimum" content for certain surveying courses. Also revised were the recommendations proposed by the 1937 conference (*ENR* Aug. 26, 1937, p. 334). Adopted was a resolution endorsing the recommendations for extension of government control and topographic surveys as made in Senate Document 54, a joint report of the Secretaries of War, Commerce and the Interior.

An inspection trip to nearby points at which laboratory or survey work was in progress broke the routine of papers near the middle of the Aug. 8 session.

The conference was conducted under the auspices of Committee VIII, Surveying and Geodesy, of the Civil Engineering Division of the Society for the Promotion of Engineering Education. The committee in charge of planning and conducting the conference consisted of: Charles O. Roth, Jr., of Cooper Union Institute of Technology, chairman; Herbert M. Dibert, of W. & L. E. Gurley Co.; John S. Dodds, Iowa State College; Malcolm S. Douglas, Case School of Applied Science; George H. Harding, University of Louisville; H. Oakley Sharp, Rensselaer Polytechnic Institute; and Douglas S. Trowbridge, New York University.

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## Missouri road body aids military employees

Employees of the Missouri State Highway Commission have been assured they will not lose their jobs if called for active military service. In telling of the action the roads commission has reported a policy of "granting a leave of absence for employees called into the service and upon the expiration of such service they will be reinstated in the same position and at the same salary received at the beginning of the leave." It is also pointed out that "The commission wishes it clearly understood that all such employees, by reason of having been called into the national defense service, would not in any way be penalized for such service, and the leave of absence would in no way affect their seniority or right of prior preference over any employee who might be promoted."

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## Illinois continues mosquito abatement work

With the cities of Beardstown, Dupo and Cairo, considering the formation of mosquito abatement districts and with six such districts already formed, state sanitary engineers of Illinois see a large improvement in the abatement work in the near future. Action on the part of these cities has been voluntary. It is in harmony with the plans of the Board of State Health Commissioners of the Upper Mississippi River Basin.

***Surveying teachers go to school for seven days at Ohio conference***

# Comment and Discussion

**Readers' opinions on matters that concern engineers and contractors**

### First Bethlehem Waterworks

Sir: The interesting article in the July 4, 1940, issue of *ENR*, describing the new waterworks system for Bethlehem, Pa., brings to mind the works completed for Bethlehem in 1761 "after severe struggles" extending through seven years. Hans Christopher Christiansen, a millwright from Denmark, was the builder. A 5-in. lignum-vitae pump driven by water power forced spring water through bored hemlock logs to a tank in the village square 70 ft. above the pump. From there it was distributed to other parts of the city through pitch-pine bored logs.

The wooden pump was soon replaced by three iron pumps of 4-in. bore and having an 18-in. stroke made by a local blacksmith at a cost of 8£, 12s., 4d. These pumps were the first built in the United States for a municipal water supply. (A gravity supply for Boston was introduced a century earlier.)

According to an article published in *Engineering News*, April 29, 1882, the earlier works at Bethlehem were visited by many notables who inscribed their names in a register. Since during the period 1768 to 1782 those registering included Governor Penn and Lady, Gen. George Washington, and Washington's adjutants, it would be interesting to know whether this register has been preserved.

M. N. BAKER
*Associate Editor (retired), ENR*
*Upper Montclair, N. J.*

### Weight of Pile Hammers

Sir: On p. 54 of the Aug. 1 issue is a very interesting article entitled "Weight of Pile Hammers." This article refers to the studies of the committee on bridges and trestles of the American Railway Engineering Association.

We are entirely in accord with the recommendations that this committee has made to the association as outlined in the second paragraph of the article which refers to the necessity of having a ram of sufficient weight and energy to overcome the inertia of the pile leaving sufficient energy to obtain maximum penetration per blow without appreciable damage to the pile.

Under the third paragraph headed "Steam Hammers" we feel that a mistake has been made either in the recommendation or in the printing of this A.R.E.A. committee report. This paragraph states that for driving concrete piles the energy developed per blow shall be at least 8,750 foot-pounds per cubic yard of concrete contained in the pile. This is far in excess of common practice and, if followed, would require hammers more powerful than have ever been built. A 24-ft. x 24-in. x 54-ft. square concrete pile would contain eight cu. yd. This is only a medium-sized concrete pile, as a great many piles have been driven containing up to 16 cu. yd. If the requirements specified were in effect an 8-cu.yd. pile would require a hammer developing a 70,000-ft.-lb. blow, which is far in excess of the foot-pound blow developed by any hammer so far built.

Some years ago the Bureau of Public Roads brought out specifications stipulating that the blow developed by a steam hammer for driving concrete piles should be at least 3,500 foot-pounds per cubic yard of concrete contained in the pile. We feel that even this requirement is excessive based on our years of experience in furnishing hammers for driving concrete piles.

Recently one of the midwest railroads made a careful study of hammers for driving precast concrete piles and in order to obtain the best information possible they used different sizes and makes of hammers on their work. The piles driven were 30-in. octagonal piles with a 15-in. hollow core extending to within 5 ft. of the point, approximately 85 ft. long weighing about 25 tons and containing 12 cu.yd. of concrete. Among the hammers tried was one of our special 14,000-lb. ram hammers which is the heaviest ram hammer ever built, and according to the information which we received these massive piles were driven to the full penetration required without any damage to the pile although the hammer only developed a 37,500 ft.-lb. blow. With the specifications as outlined in the article referred to, a 37,500 ft.-lb. blow hammer could only be used in driving piles containing less than 4½ cu.yd. of concrete, although as stated above, these piles contained 12 cu.yd. of concrete.

We feel that a mistake exists somewhere in these recommendations and would appreciate having the opportunity of discussing this matter with the committee making these recommendations as it would undoubtedly cause a great deal of trouble and needless cost on their piledriving work if such specifications were adopted by the association.

L. H. BUTTENHEIM
*Vice President*
*McKiernan-Terry Corporation*
*New York, N. Y.*

### Safeguarding Utilities

Sir: With respect to the article on "Sabotage and Water Service," (*ENR*, July 18, 1940, p. 86) I wish to commend its timeliness, and the farsightedness of the water-supply officials who are taking appropriate steps to guard their services from such destructive tendencies.

But I would like to inquire if these same officials, or others, have given serious thought to what they would or might do to defend their structures from destructive airplane attacks in case of war? Would they, and other utilities as well, depend solely upon the armed forces using anti-aircraft artillery and defending planes? If so, I am afraid that we would suffer severe losses of plants and service.

In our country with its vast, far-flung array of utility and industrial works, it is manifestly impossible to concentrate at every vulnerable works sufficient planes and artillery for an adequate defense. America should give serious thought to home-defense measures and to a comprehensive program of research to develop both improved and new methods of local defense, as distinguished from the mobile professional armed forces.

There are a number of defense possibilities that should be explored including large-scale experiments with smoke clouds or artificial fogs. The use of artificial fogs in the form of "smoke-screens" has been developed to a high degree of efficiency for concealing the movement of troops

from the enemy: but the use of smoke "blankets" to conceal vulnerable targets from airplane observation and attacks has received little or no attention. With proper research seeking the most effective and economical method of producing concealing smokes, under the conditions required and under the various limitations imposed by the meteorological conditions of wind and weather, much valuable information could be secured of great possible value for home-defense operations.

There are a number of other possibilities of entirely undetermined value which will not be imposed upon the attention of the reader at this time.

HOMER G. SHOCKLEY
*Professional Engineer*
*Brooklyn, New York*

## Engineering Council

Sir: I have read your editorial headed "Engineering Council" in the Aug. 15 issue. A sense of duty to the engineering profession as a whole prompts me to express my beliefs concerning the field of usefulness of American Engineering Council. These beliefs are based largely on my experiences while president of the council from 1921 to 1923. I had the honor to succeed Herbert Hoover when he became Secretary of Commerce under President Harding. I had the feeling then, and still have, that the usefulness of American Engineering Council, not only to the engineering profession but to the country at large, has never been fully appreciated by some, if not all, of its member societies.

So far as I know, there is not an engineer in Congress. So, all too often I fear, the engineer is looked upon as a hired man. And yet, he is responsible not only for the material structure of our modern civilization, but for its effects upon our spirital development. And what, may I ask, is the engineering profession doing or going to do about it? It is not a matter for the individual engineer or for a single engineering society alone; but for all engineers, and all societies acting together. I like to think that it was in some such spirit that American Engineering Council was conceived.

American Engineering Council can in the future, as it has in the past, perform a great service not only for the profession but for the country at large. Through it great help can be rendered Congress and the executive departments of the government. To illustrate: Following the great floods on the Mississippi in 1921 or 1922, Congress proposed to establish laboratories for the study of flood control; and legislation was introduced to that end. Arriving in Washington on one of my monthly trips to attend Council matters, I found awaiting me a message from the chairman in charge of this legislation. I went to the Capitol at once and was asked by the chairman to enlist the backing of engineers. I suggested it was a matter in which civil engineers were primarily interested. At that he exclaimed: "I don't want any one single society behind me; I want the entire engineering profession—and that, I understand, the Council represents."

In the first paragraph of your article you state: "The idea back of Engineering Council was good, but earily in its career its administrative officers tied it so tightly to the political kite of its first president, Herbert Hoover, as to ruin its effectiveness as a non-partisan agency."

That statement I regard as very unfair to Mr. Hoover. I went to his office monthly to confer on Council affairs and got to know him rather intimately. I feel I can justly say that rarely in the history of our country has there been a man in political office less politically minded. And I may add that were the engineering profession more politically minded than it is, the affairs of our government would proceed along quite different lines.

In your second paragraph, you say the civil engineers were slow to come in to the Council at the start. Civil engineers are conservative. They and the surveyors ahead of them have always dealt with matters that developed conservatism. Rarely do they follow a course of action not based on known facts. Thus, they were slow in joining and have followed rather than led in its development.

In your third paragraph referring to the work of American Engineering Council, you say that most if not all could have been equally well done by one of the Founder Societies. In view of what I have said previously, it is evident that I do not consider this statement correct. The engineering profession as a whole can accomplish vastly more than any one of its component parts.

If American Engineering Council has in the performance of its functions failed, then there must of course be a reason for it; as with a machine the natural thing is to condition it properly. Surely there is no lack of ability in the engineering profession to bring this about.

Without going further into detail, let me say in conclusion that I am in full-hearted agreement with the statement in your last paragraph: "Before it [A.E.C.] is abandoned, it should be permitted to demonstrate what it can do in the way of keeping engineers informed as to what it sees and hears in Washington."

To that I would add it should further be permitted to demonstrate what it can do as a medium through which the voice of the engineering profession throughout the entire country can be heard, in the halls of Congress and in the administrative offices in control of national affairs.

MORTIMER E. COOLEY
*Dean Emeritus*
*College of Engineering,*
*University of Michigan*

## Honors for Engineers

Sir: I read in the *Engineering News-Record* of July 25, on p. 128, under the head of "Men and Jobs", an account that Perry Ford had recently been made an honorary member of the "Société des Ingénieurs Professionels of France".

I was glad to see this note, but thought you would like to know that at the same time that this honor was conferred on Perry T. Ford, the following members of the National Society of Professional Engineers were also honored:

David B. Steinman, Past President, N.S.P.E.
Arthur V. Sheridan, Past President
John C. Riedel, President
Samuel I. Sacks, Vice President
Walter I. Simpson, Treasurer
Willard S. Conlon, Executive Secretary
Robert Hall Craig, Editor, *The American Engineer*

The letter transmitting the honorary membership was sent in May of 1940, probably one of the last acts of the Société des Ingénieurs Professionnels of Paris, in the Republic of France.

JOHN C. RIEDEL
*President, N.S.P.E.*
*Washington, D. C.*

# EDITORIALS

Volume 125 Number 9

*August 29, 1940*

## Making Tunneling History

TEN able, experienced, and well-financed contracting organizations are engaged on the Delaware Aqueduct in building the largest and longest continuous tunnel ever undertaken; 83.8 miles is its length from high in the Catskill Mountains to New York City. That not all thought alike with respect to procedure is evidenced by the different methods in use and the new equipment developed, as outlined elsewhere in this issue. The fact that each project is at least abreast of schedule is evidence of thorough preliminary investigation and practical design by the engineers; of careful estimating and wise planning by the contractors; and above all of a workable contract and effective cooperation of an engineering force that knows tunneling. At this time most of the known bad ground has been passed and excavation on several contracts completed so that success of the project, without change from the original design plan or construction plants, seems assured.

## Watch Your Reactions

DISCOVERY of the large influence on stresses of warping of a bridge during erection adds an important item to knowledge of bridge action. The discovery involves two facts: first, that a substantial amount of warp may develop in a bridge during cantilever erection, and second that this warp changes the stress distribution seriously because of the high twist resistance of a well braced bridge. Taken together, these two facts mean that in cantilever erection it is well to be careful that the contour of the two trusses is kept alike. They also suggest that weighing the truss reactions when jacking to final position is advisable in the interests of efficiency of the structure. Conditions such as described by Prof. Wyly would not ordinarily arise in falsework erection, but any settlement of falsework would disturb the identity of contour of the two trusses, and the field engineer should take care to prevent it. The designer also has an interest in the Illinois discovery: the possible stress addition resulting from inequality of reactions due to warp may cut perceptibly into the safety margin unless advance allowance is made for it in the working stresses chosen for the design.

## Timber Test Opportunity

WITHIN A FEW MONTHS large timber structures with trusses and joints of various types will be demolished on the site of San Francisco's exposition. A committee of structural engineers has outlined tests that it would be desirable to make on the large timber joints, and, if funds are available, on the entire trusses, which, in the main structures, range up to 200-ft. span. When these structures were designed certain assumptions were made as a basis for calculation, and full-scale tests would show what the factor of safety is on those assumptions. Much more interest and much less cost would attach to this test program than in the case of specimens built expressly for laboratory destruction. Altogether, this is a rare opportunity to check basic assumptions of structural timber design. It would be a real loss to miss this chance for full-scale tests.

## High-Speed Engineering

HIGH-SPEED CONSTRUCTION sometimes calls for high-speed engineering, to plan a large volume of intricate work at breakneck speed. This is especially so when contractor and engineer start on the job almost simultaneously. In fact, at times in large operations the constructor treads on the heels of the engineer, or even steps out ahead, as at Fort Peck and Grand Coulee, and the record proves that this can be done without serious results. But even so, the job done by the bridge division of the Pennsylvania Turnpike was a star performance, and quite fittingly the pace of R. F. Graef's account in this issue reflects the push and drive of the work itself. Designing nearly 300 bridges in eight months' time is a record likely to stand for a while, and the way in which standardization of types was coupled with free adaptation of type to local conditions makes the record additionally interesting. Noteworthy points in the work are the commendably heavy loading adopted and the extensive use of rigid frame structures. The latter confirms the strength of position which the rigid frame type has gained, though the comparative costs given indicate that economy is not a controlling consideration.

## Bottleneck in Congress

NATIONAL DEFENSE CONSTRUCTION is advancing at only half speed as a result of congressional dallying over legislation relating to conscription, excess profits and amortization of investments in war industry plants. The quick appropriation of money which resulted in the rapid letting of contracts on naval base construction and a good beginning on army construction work is not being matched by similar action that would speed up industrial plant expansion. Probably the answer lies in the fact that it is always good politics to appropriate money, while Congress can't decide what is the best politics on the questions that now confront it. At any rate the failure to get needed construction under way rests solely on the shoulders of Congress.

Take the matter of barracks, for example. It was not until last week that the War Department could feel certain enough of congressional action on the bill giving the President power to call out the National Guard for peacetime training to contract for any living quarters. Passage of this bill was almost a foregone conclusion, yet it has taken six weeks for it to get through the congressional mill. It is equally certain that a conscription bill will be passed, but Congress continues to debate inconsequential points while contracts for hundreds of barracks are held up.

Then there are the subjects of excess profits taxes on all war business and the amortization schedules on plants built exclusively for munitions manufacture. For some inexplicable reason both are hooked together in the same bill. Excess profits present a difficult question that only careful study and debate can solve; that will take time and has no real relation to industrial plant expansion. An amortization period, on the other hand, could be agreed upon in 24 hours, and it has a vital effect on factory building because industry, which will take a chance on profit, cannot and should not gamble with its investment in a plant that will be but an idle barn when war orders cease. If Congress would settle the amortization question in a separate bill, factory construction would leap ahead.

The broad consequences of congressional failure to implement the national defense program by every means possible and with greatest speed are so overpowering that the effect on the construction industry is unimportant by comparison. Yet it is of some importance that the new soldiers will need barracks the very first thing and that munitions of war cannot be manufactured until the plants are built. Every day's delay means that much more high-pressure work, with the ever-present possibility that no amount of effort can meet the desired construction schedules. If during this time Congress should be interested in the location of the bottleneck it will need only look in a mirror.

## Wage-Rate Uncertainty

THE BASIC cost-plus-a-fixed-fee contract for Army emergency construction contains clauses relating to wage rates that need to be clarified if delay and trouble for the contractors are to be avoided. The contract provides that "wage rates not less than those established by the Secretary of Labor" shall be paid. This provision appears innocent enough until read alongside two subsequent clauses. One of these clauses says that if the contractor is found to be paying wage rates less than those set by the Labor Department the contract may be canceled, in which case the contractor will be liable to the government for excess costs resulting from having to take over the contract; the other clause says that if the contractor pays more than the prescribed rate the excess comes out of his own pocket. Obviously, unless wage rates are fixed right at the start of the job, the contractor may run foul of one of these provisions.

Contractors who are offered these contracts should urge the Army to be clear and definite with respect to when and how wage rates are to be established. A desirable change would be substitution of the plan followed by the Navy under which the contracting officer himself fixes rates. But if wage fixing is to be done by the Labor Department, the contract should set the date before which the rates shall be prescribed, and it should contain a provision protecting the contractor against losses due to changes in the rates made during the life of the contract. Such provisions will injure no one, indeed will make for increased economy and efficiency.

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*Fig. 1. Completed trans-Everglades road of rockfill with a bituminous surface treatment.*

# New 69-Mile Everglades Highway

***Contents in Brief**—A new road through the Florida Everglades shows the latest development in road structure for this great swampland area, a rockfill in a muck trench excavated to rock. Dragline excavators and drillboats take the place of the more familiar grading machines in this type of highway construction.*

A NEW HIGHWAY is being completed through the Florida Everglades. This is the major roadbuilding operation in America's greatest marshland area since the construction of the Tamiami Trail some fifteen years ago introduced distinctive methods and equipment for swamp road construction.

The map, Fig. 2, of southern Florida shows the three notable highways of that section of the state. The new Everglades road connects with cross-state road 25 at South Bay on Lake Okeechobee, and runs south to Miami and Fort Lauderdale. The Tamiami Trail is shown extending west from Miami to the Gulf coast and then north to Fort Myers. The map also shows the unique overseas highway to Key West described in *Engineering News-Record*, Sept. 2, 1937, which is coupled in construction interest with these great morass highways.

### Route and structure

From South Bay to connections with the entrance roads to Miami and Fort Lauderdale, the New Everglades highway is 69 miles long. From South Bay to Fort Lauderdale the route parallels the North New River Canal; sections A and B, Fig. 2, embrace this part of the road. Section C, 13 miles long, is across open marsh. The excavation for the road along the canal is 60 ft. away from the canal prism and the rock for the road fill is dug from the rock bottom of the canal or taken from the old spoil bank. The 13 miles of highway across open marsh is in excavated trench to rock and the fill is made from rock excavated from the bottom of a parallel borrowpit trench. In all cases the roadway fill is 30 ft. wide on top, which is set at an elevation 2 ft. higher than any known high water, and it has 1 on 4 side slopes.

The Everglades are essentially a huge rock saucer which is filled with the decayed vegetation of ages on which grows saw grass and flags. At high water the muck bed is submerged and the water appears in pools and ponds among the grass and flags; always the muck, which is from zero to 10 ft. deep to rock, is soft and, except for occasional hummocks, is dry only in its top part. To keep the water level down for truck farming, the state of Florida has at various times constructed drainage canals from the interior of the swamp area to the ocean. Several of these canals are indicated on Fig. 2. The canal cut is made only through the muck until it shallows as the rock bottom slants up toward the edge of the saucer and then the bottom cut is deeper and deeper in rock. For example, the North New River Canal paralleled by the new road was cut only to rock for about the length of Section A, Fig. 2; then for Section B, Fig. 2, the bottom cut was in rock with spoil banks on both sides. These banks are mentioned because they influenced the methods of road construction described later.

The rock under the Everglades is a limestone in the sense that it is predominantly carbonate of lime from coral and shells, with intrusions of flint. It varies widely in structure and degree of hardness but it all requires blasting for economical excavation. Generally, this rock, when excavated wet and so deposited in a wet trench for road fill, is soft enough to coalesce and settle down into a compact embankment. Then to make a road, the rock surface is scarified, shaped, rolled and water bound, and given a tar primer to bond a single bitu-

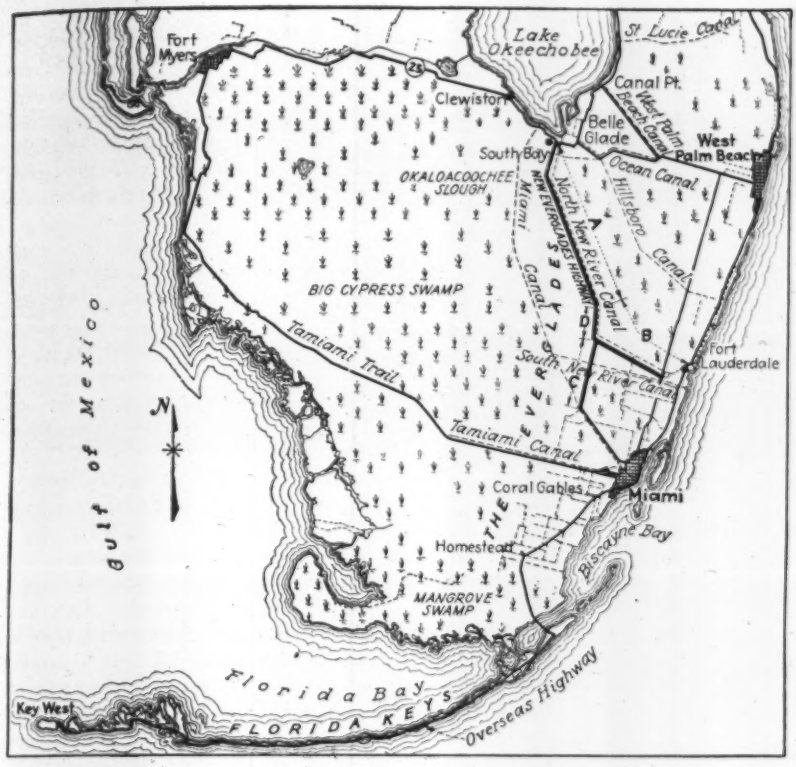


***Fig. 2. Southern Florida showing the swamp roads of the Everglades and the unique overseas road to Key West.***

minous treatment with a stone cover.

Parts of the road made from dry rock, taken as stated from the old canal spoil banks along Section B, required a rolled fill. The dry rock was spread in 8-in. layers the full width of the cross-section and the layers were compacted by bulldozers and rollers. Also the specifications required that: "No rock that will not pass a 12-in. ring shall be placed within the top 4 ft. of the completed embankment; no pieces of rock that will not pass a 6-in. ring shall be placed within the top 2 ft. of the completed embankment, and no pieces of rock that will not pass a 3-in. ring shall be placed within the top 12 in. of the completed embankment."

As shown by Fig. 2, the road was constructed in three sections, A and B parallel to the North New River Canal, and Section C across open swamp. In section A, 35 miles, the parallel canal had been excavated only to rock, and borrow for the road fill was obtained by widening the rock bottom of the canal and deepening it to 16 ft. below road grade. The work was done by contract with The George D. Auchter Co., Jacksonville, Fla.

In Section B, the rock for road fill was obtained from the rock spoil banks of the canal completed several years previously. In this section of canal the upslant to the edge of the rock saucer made a bottom cut in rock necessary—very shallow in Section D and then increasingly deeper east to the saucer edge. The shallow rock cut of Section D made it necessary to use rock from both spoil banks for the road fill. The contractor for Section B was the Badgett Construction Co., Memphis, Tenn. This section was 21 miles long.

With Section C the work departed from the drainage canal and struck across swamp for 13 miles. Here, for 8 months of the 14 months required to complete the work, water stood on the surface in ponds and pools and the muck cover was from 1 ft. to 10 ft. deep. A cut to rock 30 ft. wide, with 1 on 1 side slopes, was made for the road fill and a parallel cut 50 ft., with 1½ on 1 side slopes, was made for the rock borrow. The two cuts were 125 ft. apart, center to center. The contractor was again The George D. Auchter Co.

### Plant and methods

This marsh roadbuilding was almost a water-borne plant operation. The most completely water-borne operation was Section A, and this is described as typifying characteristic methods and machines. Three dragline excavators and a drillboat were the main equipment and they operated in the order shown by the diagram, Fig. 3.

Dragline 1, working ahead in a succession of loop movements, each covering about half a mile of road, performed three tasks. On the first forward trip, *a-b*, Fig. 3, it cleared the canal of the tangled growth of water hyacinth which clogs most Florida streams. Looping back from *b* to *c* the dragline cleared the rock bottom of the canal of its accumulated mud. On the second forward trip, *c-d*, the machine dug the channel for the road and then swung from *d* to *e* for another series of operations. With the canal cleared to rock bottom the drillboat drilled and blasted the borrow rock for road fill. Draglines 2 and 3 dug the blasted canal rock and placed it in the rockfill. Machine 2

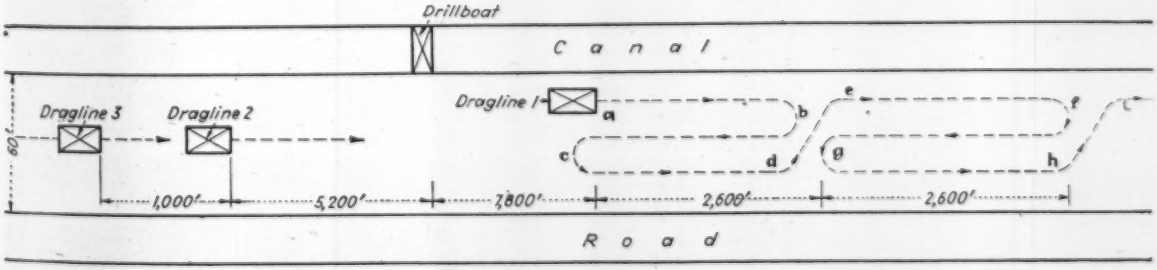


***Fig. 3. Schematic diagram of main equipment operations on a section of the new Everglades highway.***

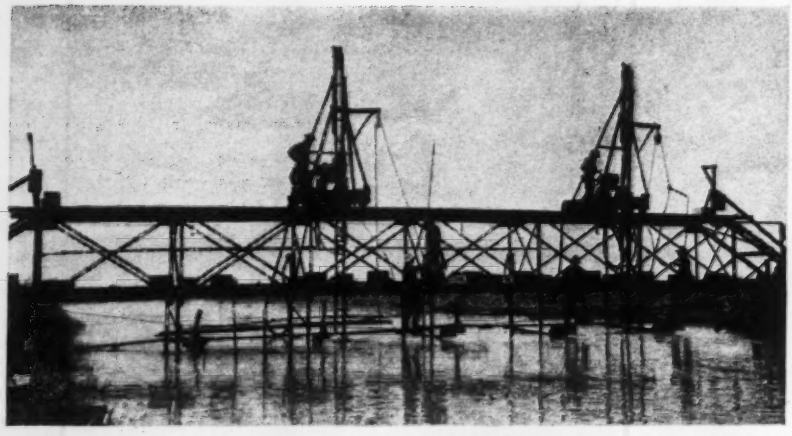

***Fig. 4. A bridge spanning the borrowpit cut carried drills for rock blasting to make the road fill.***

cleaned the road cut of its last bottom mud and placed the first rockfill; Machine 3 then did the main filling.

Dragline 1 had a 60-ft. boom and a 2-yd. bucket for digging and a job-made special bucket for hyacinth removal. This special bucket had a grid bottom of round rods so that the water would drain out quickly in lifting a mass of plants. In operation, the dragline tore the plants loose from the bottom and men in boats pushed them together into masses on top of the water, from where they were dipped by the grid bucket and wasted. A standard Red Arch bucket was used for digging the muck. Machine 2 had a 70-ft. boom and a 2-yd. Page bucket, and Machine 3 had a 100-ft. boom and used both Page and Red Arch 4½-yd. buckets. All the draglines were operated from mats made up of 3x6-in. timber in laminated sections 10x20 ft. and 9 in. thick.

The drill barge virtually spanned the width of the canal. It had three drills carried on a truck along the deck and operated by two air compressors. The holes were drilled through 8 or 9 ft. of water in lines across the canal; they were drilled 5 ft. apart and 8 ft. deep; the blasting charge was 12 sticks of dynamite per hole. All operations of the drill barge, the draglines and other plant were 24 hr. a day and 6 days a week.

On Section B, Fig. 2, somewhat different conditions influenced the selection of plant. Dragline operations in digging the trench for the roadfill were not essentially different, but as rock from the spoil banks of the canal was used for the fill there was no hyacinth or mud removal from the canal and no amount of drilling for borrow rock. Generally, there was enough rock for the roadfill in the spoil bank adjacent to the fill. On part D of Section B, where the rock cut in the canal was shallow, there was not enough fill material in one spoil bank and both were drawn upon. A screening plant, Fig. 5, was installed on the far bank; a belt conveyor took the screened material across the canal to the road fill, and screen rejects (over 12-in. size) were returned to the spoil bank. A bulldozer on the roadfill leveled off the discharge from the belt conveyor.

Section C, unlike the others, was across open swamp that had never before been excavated. Two cuts were made through the muck to rock, one for the road fill and a parallel excavation to expose borrow rock for the fill. This rock was drilled from a bridge spanning the cut and resting at the ends on flat cars on bankside tracks. The cuts and rockfill were made by draglines.

These fine examples of marsh roadbuilding have been designed and constructed under the direction of the Florida state road department, J. H. Dowling, state highway engineer, E. C. De Garmo, division engineer. We are particularly obligated to Earl Hendrickson, project engineer, for details of the operations.

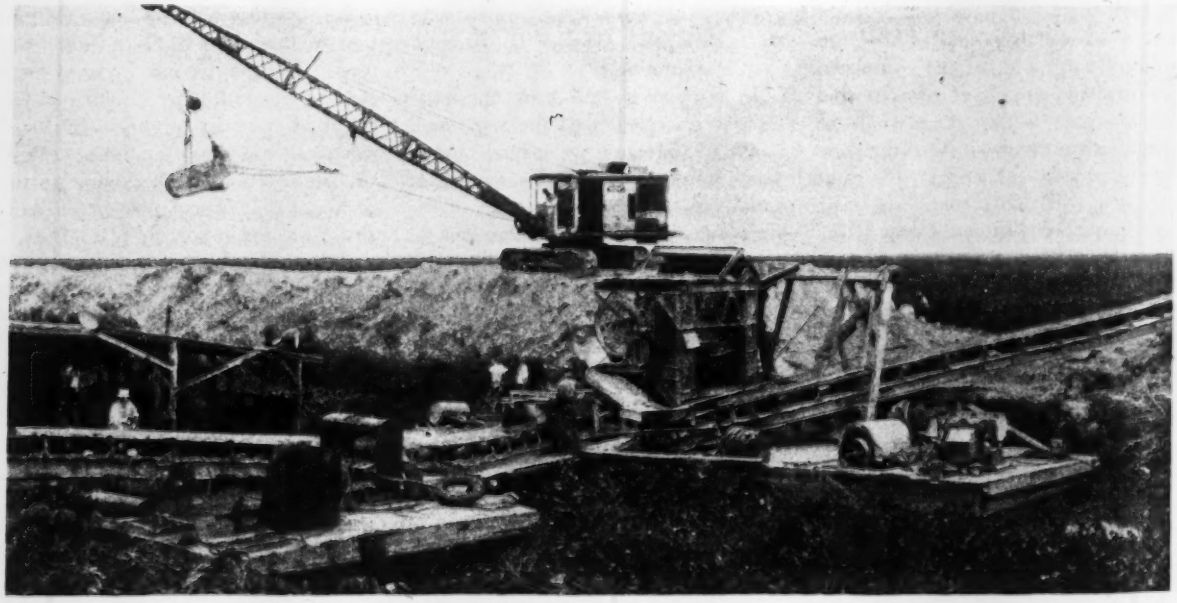

***Fig. 5. Rock in the canal spoil bank was screened and conveyed by belt to the road fill on one section of the highway.***

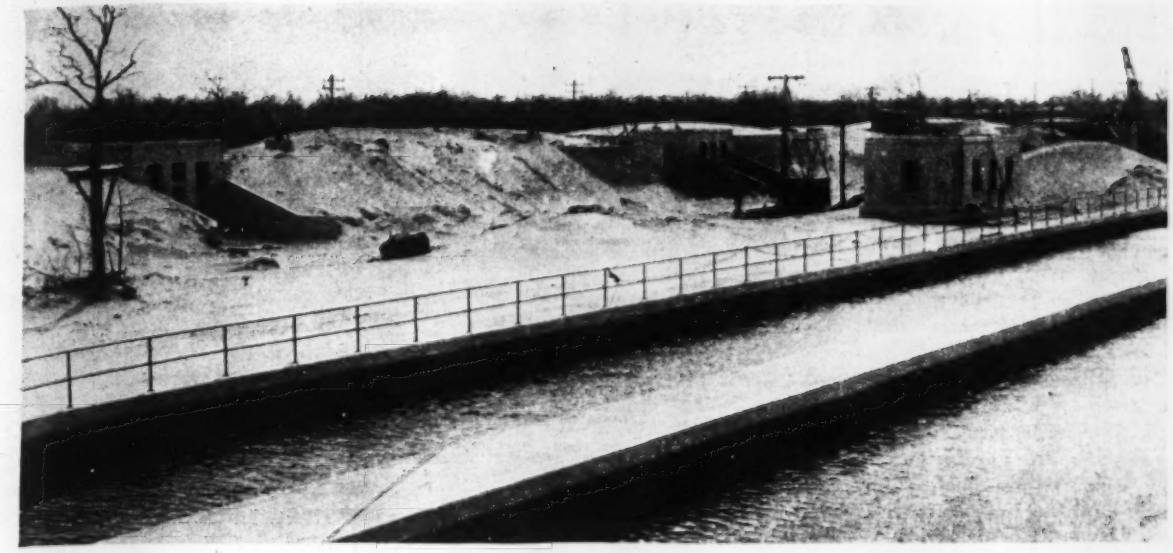

*Fig. 1. Not snow but the white sand of Gary piled around the digestion tanks. In the foreground are the aeration tanks.*

# Garbage Grinding at Gary

***Contents in Brief**—Newly developed equipment for more economical operation is incorporated in the Gary, Ind., activated sludge treatment works, where garbage will be handled along with sewage wastes. It is estimated that the gas produced by grinding garbage at the plant for ultimate digestion will have an annual value of over $13,000. The following highlights of plant design are from a description given by L. R. Howson, consulting engineer, before the Central States Sewage Works Association.*

GARBAGE GRINDING FACILITIES, use of stationary tube diffusers for aeration and automatic control are features of the new activated sludge sewage treatment works now under construction at Gary, Ind.

The basis of design is as follows: population, 170,000 (now 100,000); average flow, 40 mgd; peak flow, 60 mgd; settling and pumping capacities, 90 mgd; 5-day B.O.D. 111 ppm; suspended solids, 120 ppm. Gary is sewered on the combined plan.

Of special interest in the plant are a screening chamber which houses five comminutors so designed that under the maximum rate of flow of 60 mgd the loss of head will not exceed 15 in.; use of low pump inlet velocity of 7 fps because of the high suction lift of 14 to 16 ft.; and automatic float controls for the gas engine units.

Under the Indiana Sanitary District Law the Board of Commissioners is charged with disposal of the garbage, as well as the sanitary wastes. Engineers recommended that "the least expensive and the best plan for garbage disposal for Gary would be to grind the garbage into the sewers for disposal with the sewage and that the remaining combustible refuse should be burned in the present incinerator."

So far as the sewage treatment plant is concerned, this recommendation involves the installation of a grinding station over the main sewer at the entrance to the sewage treatment plant grounds and the construction of three additional digesters. Not the least among the factors leading to the above recommendation was the value of the additional gas which would be secured from digestion of the garbage solids. It was estimated that the value of this would amount to from $13,000 to $19,500 per year, in terms of equivalent power otherwise purchased.

Chief among the automatic features are the provisions made for control of pumping. Each sewage pump is provided with an automatic cone type discharge valve. Pumps will be primed continuously. The motor-driven pump switch circuits will be interlocked with the solenoid circuit of the discharge cone valve, and the priming valve switch circuit is connected with the motor control to prevent starting of the pump when not fully primed.

The priming valve switch of the gas engine-driven units is interlocked with the engine ignition circuit so that the engine cannot be started unless the pump is primed; the engine is also interlocked with the cone valve solenoid circuit so that the valve will start closing immediately when the engine is shut down manually or otherwise. Noise and vibration of the gas engine units are reduced by mounting on spring vibration dampers.

The two mechanically-cleaned grit washers in chambers providing for 1-min. detention, have dragline conveyors pulling the grit to a sump from which it is elevated by worm screw conveyors to an elevation which

permits of discharge into dump cars. A primary settling period of 1 hr. is provided. The four primary clarifiers are of the central radial flow type.

### Stationary diffuser tubes

Aeration tanks are ten in number, each 30 ft. wide by 15 ft. water depth and 300 ft. long. Basins are of the spiral-flow type with air diffusion through 225 stationary diffusion tubes 3 in. in internal diameter by 24 in. long.

The tubes are staggered along the header so as to give a spacing of 1 ft. 4 in. The permeability rating of the tubes is 40. The design is based upon a normal use of air at the rate of 0.4 cu.ft. per gal. of sewage with sufficient capacity provided in the air header and the tubes to take care of 1 cu. ft. The retention period in the aeration tanks is 5 hr. for the sewage plus 25 per cent return sludge. Tubes are set 24 in. above the floor of the aeration tanks.

Factors affecting the selection of fixed tubes instead of plates for air diffusion at Gary include: (1) saving in first cost estimated at $15,000; (2) some saving in annual cost because of 2 ft. less head on the blowers; (3) advantages during periods when tanks are cut out of service as will frequently be the case at Gary in the early years of low-flow operation.

The secondary settling tanks duplicate the primary tanks but are of double the capacity with equivalent daily rates of 900 gal. per sq. ft. Of the six 125,000-cu.ft. circular digesters, two have floating covers for gas storage of 70,000 cu.ft. each. The roofs of the four fixed-cover digesters are of flat slab on columns of reinforced concrete construction, which comparative figures indicated are materially less costly than all-steel construction.

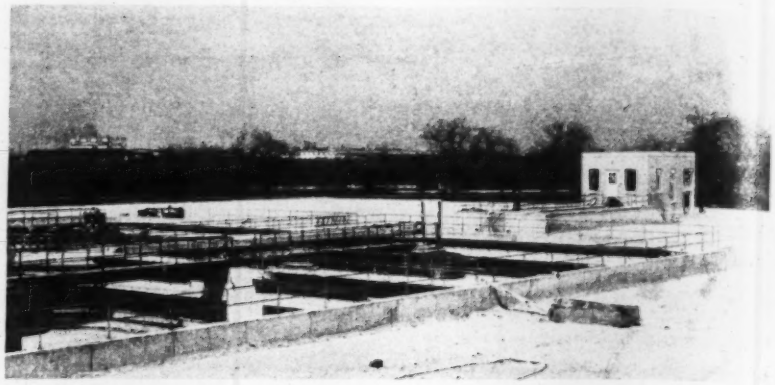

***Fig. 3. Four clarifiers of the central radial flow type are shown in the foreground. At the rear, screen house and grit chamber.***

The total sludge digestion capacity is equivalent to 4.5 cu.ft. per capita for the 170,000 population design capacity.

The treatment plant site is covered with fine lake sand extending to considerable depth. It was unnecessary, therefore to underdrain the sludge-drying sand beds. The sludge bed has an area of 340,000 sq.ft., equivalent to 2 sq.ft. per capita. Industrial tracks are laid to a dump and to a concrete loading platform.

It is anticipated that at Gary there will be a real demand for sludge, as with the drifting character of the sand surface it is necessary to haul in quantities of black topping dirt. Sludge can be used for this purpose.

The cost of the sewage treatment project exclusive of the $175,000 garbage grinding plant is $1,715,545, equivalent to $42,816 per 1-mgd capacity.

The Indiana Sanitary District Law sets up an appointive non-political board of engineers for administration. At Gary this board consists of Ralph Rowley, engineer for the Illinois Steel Co., W. F. Cottington, for over 20 years city engineer, and Boyd E. Phelps, an engineer with a background of construction experience principally in highway work. Alvord, Burdick and Howson are engineers, with W. W. Mathews as their resident engineer in charge of construction. The principal construction contracts are held by the Permanent Construction Co., and Strandberg and Spencer, Inc., of Chicago.

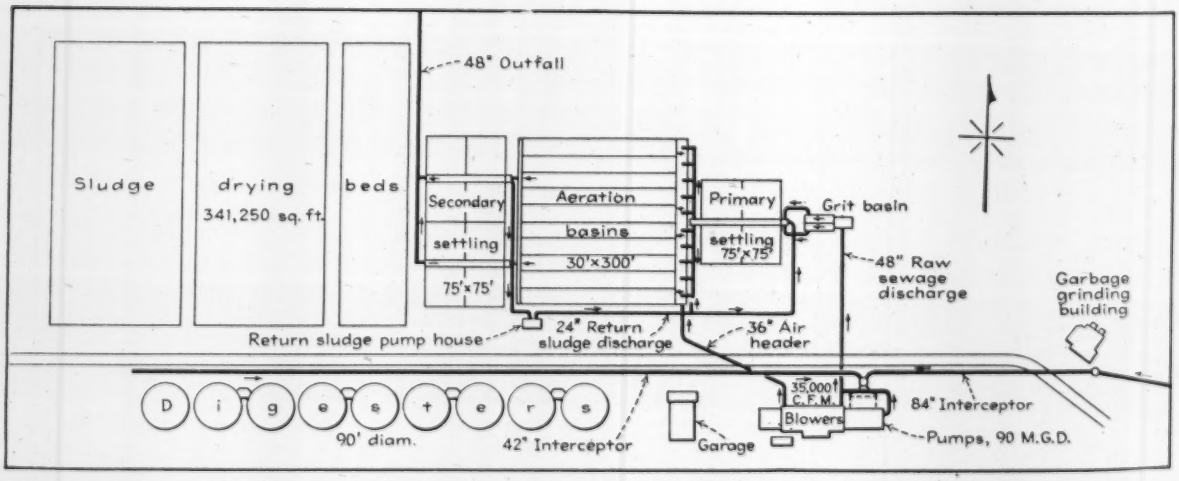


***Fig. 2. General layout of the Gary sewage and garbage disposal plant. Extra digestion tanks are provided to accommodate ground garbage, and the resulting gas generated will have a value of over $1,000 a month.***

# Why Building Costs Are High

**Jacob Mark**
Professional Engineer, Brooklyn, N. Y.

***Contents in Brief—Building remains low in the face of demand and need for millions of housing units because of excessive costs. Causes of high costs include interest rates and service charges, wage rates and union rules, unprogressive code requirements and restrictive practices of material men.***

THE BUILDING INDUSTRY is news not because of the great quantity of building, but because of the relative lack of construction. This is true in housing despite the large number of jobs which are now in progress. Statistics indicate that the best recent years have shown less than one-half the building volume which prevailed in any of the years of the decade prior to 1929.

Millions of housing units are needed and wanted. Yet, while all industry except construction has been stepped up to near the 1929 level and while there is a greater need for housing than for any other commodity, that need is not being filled, and great numbers of building trades craftsmen and technicians remain unemployed.

The basic reason for the inability of investors and speculators to fill the needs of waiting customers lies in high costs of construction, which raise the price of housing above what prospective tenants or purchasers can pay. Manual-labor methods in housebuilding that carry over from the Egyptian period are in part responsible for these excessive costs. The average family has earnings of about $1,500 per year or about $4 per day; the head of such a family cannot get a fair exchange for his labor in the purchase of living space built with hand labor earning two or three times as much.

### Money costs too much

One of the factors of high building costs is the price of building money. On privately financed projects lending institutions charge interest rates between 4½ per cent and 6 per cent, in addition to servicing charges. These rates are high, despite the official support of such rates by the FHA. Banks, paying only 2 per cent interest to depositors, have a greater spread between interest paid and collected than they had prior to 1929. If interest could be lowered 2 per cent, one of the continuing heavy costs of housing could be reduced.

Title companies still exact charges for title policies, without which loans will not be made; this despite the fact that most title companies went under in the last decade. They have prevented adoption of state registration laws which could save home buyers sizable sums.

In the present money market the FHA and local housing authorities sell short-term housing obligations at interest rates of less than ½ per cent per annum, yet the same institutions that buy these obligations will not lend to private enterprise for ten times such rates. Thereby they restrain private enterprise and encourage government building.

### The labor factor

A second factor of high cost is the attitude of field labor. The building trades unions have succeeded in procuring agreements providing for wages of $1.75 to $2 per hour which, together with social security payments, unemployment insurance, compensation insurance and normal overhead means an average cost of $2.50 per hour per man. A goodly part of the work on building is hand labor and can be expedited only with great difficulty.

On small projects these rates are not enforced, and much work is done at lower scales of pay. This situation has recently been recognized by the CIO, which is offering agreements for lower pay on small projects. The AFL has held conferences endeavoring to meet the CIO competition by establishing lower scales of pay for suburban or small projects. Labor is beginning to realize that with reasonable pay scale the men will spend more time working and less time looking for jobs. But at present the established high scales of pay are a contributing cause of unemployment of building trades workers, and they keep costs up.

Even more than wage rates, jurisdictional disputes and arbitrary labor rules continue to plague builders and raise the cost of construction. Each union makes its own laws, subject to no authority but the whims of the union leader. The delegate of each craft carries his little book in which the work claimed by his union is listed. As such work may be listed in several of the books of different crafts, the owner is frequently confronted with stoppage of his work, and sometimes pays two trades for similar work. He spends much time in adjusting disputes which he had no hand in raising.

To indicate how costly these disputes and practices are, a few only will be cited. The carpenters are continually at loggerheads with other trades where substitutes for wood are involved. They also raise conflicts in cases where other trades have to cut wood in order to install their work. A notable dispute of this sort took place at the Woodside (L. I.) housing development, where carpenters refused to permit steamfitters to cut wooden joists to give proper pitch to the steam pipes.

Electricians and plumbers will not permit laborers to handle refrigerators from truck to apartment. Electricians force the owners to provide maintenance men if overtime work is done, in order to be ready to replace blown fuses; that is about as reasonable as if every householder were required to keep a pair of electrical maintenance men on duty at all times. The electrical fixture man not only restricts the number of fixtures which a man may hang in one day, but he also restricts the plants which may do the wiring.

The tile setters have for years established a rule which permits the installation of only one bathroom of wall tile per day's work. The metal lathers have rules which keep that union in conflict with other trades

and which force cutting, bending, and fabrication of rods and other metal shapes to be done in the field. A recent dispute took place on a large city housing project where metal clips were used to fasten base. These clips had been stamped and preformed. The metal lathers tied up the job for a week; finally a labor mediator decided that the metal lathers were right, and a man from their union was assigned to the plant in order to perform the work under their union jurisdiction.

Plumbers and steamfitters have succeeded in continuing the practice of cutting and fitting small pipe work at the building site. There is no more reason for field fabrication of pipes than there would be for field fabrication of structural steel. Substantial savings could be made if fabrication and assembly of plumbing and steamfitting units were done from the engineer's drawings and the work delivered to the building for easy installation.

Steamfitters and elevator maintenance men exact a toll from builders between the time when the equipment is ready for operation and the time when a certificate of occupancy is granted. During such period the elevators, even though they may be automatic, must be operated by an elevator constructor. If there is overtime work, an electrician and a helper must also be kept at hand, in order to watch for any fuse or wire trouble. The steamfitters exact pay if a plant has to be fired should any seasonal heating be necessary. If the owner attempts to heat his building over a week-end without engaging the union crew at double time, the contractor is fined.

There are any number of other local rules that cause increases in building costs, but enough have been mentioned to indicate how they operate to push costs upward. And in addition to hampering building by rules, the unions also resist training apprentices, thus placing a premium on the available skilled men.

#### Excessive code requirements

Costs are made high also by archaic building codes. Even the latest New York Building Code discourages the economic application of sound principles of construction for fireproof buildings. It calls for 3-hr. protection for columns and other main supports, which precludes taking advantage of the economy of metal lath and stucco with air space as protection. An attempt was made to introduce what is known as Class 2 firesafe construction, but so many prohibitory provisions were added that there is no economy in extensive use of the new permitted construction forms.

#### Material prices too

Combines of material men in restraint of trade, which have made so much news through recent prosecutions by the U. S. Department of Justice, have also helped to increase building costs. Peculiarly, the increases are not due primarily to the raising of material prices, for these have been quite stable over a long period of time. For example, the wholesale price index of the U. S. Department of Labor for 1939, using 1926 as value of 100, gives iron and steel 95.8 per cent, pipe about 97 per cent, boilers 90.9 per cent, water closets 61.5 per cent, radiation for steam or water 96.9 per cent, tube 66.7 per cent and brick 90.8 per cent. Most lumber has also been below the 1926 average.

But while basic prices thus are not high, material costs have been increased by practices of the contractors which provide them with a greater spread between cost and selling price. The principal ones were open price associations—bodies whose members exchanged information with one another before submitting bids—limitation of the number of bidders according to lists agreed upon by conference among material men, jobbers, suppliers, manufacturers and unions. Such combines were made effective by quiet coercion, which in many cases was a perfectly good club.

It must be remembered that the private owner, always working against time, has not the resources to combat the combines that are set up against him. In some cases the unions will refuse to supply labor where the contractor or owner has awarded work to a non-approved subcontractor. The material men will assist by not supplying materials to other than approved subcontractors. The plasterers' union has tried to make effective a rule whereby smooth concrete ceilings may not be used, insisting that the ceiling be plastered, despite the fact that smooth concrete has been effectively and economically used. The metal lathers and plasterers have been known to sabotage and wreck jobs on which contracts were awarded to unapproved subcontractors.

Unfortunately on city housing and federal housing jobs the practices of material men and labor have been not only condoned but encouraged. In the Federal Housing Administration jobs the high labor costs are fixed by government contract.

The list of elements of high building cost that has been mentioned could be expanded to include many more examples. Their net effect will not be cleared unless there is a way found to control and subdue them. It is easier under present conditions to build a project in the suburbs where the forms of construction may be primitive than to attempt the elimination of slum areas and substituting modern housing.

#### No help from public housing

Public housing authorities are not disturbed by high costs. While they would like to get more housing for their dollars, these authorities do not go beyond procuring competitive bids from general contractors, who are obliged to work under conditions that make high costs inevitable. The private investor obviously can not compete with government agencies, for numerous reasons:

1. He has to pay taxes on the full value of the improvement.
2. He has to pay interest on a basis of 4½ per cent to 6 per cent without subsidy, whereas the government projects are subsidized for their interest.
3. He is subject to foreclosure if during any period the property can not earn the carrying charges.
4. He must get a greater rental than the government projects in order to meet the higher charges.
5. He can not pass the higher costs on to the public, whereas the government project need merely get a higher subsidy.

To overcome such disadvantages, the investing builder will have to find a way of reducing building costs through the elimination of some of the causes of high costs as mentioned. Failing in that, building will have to go forward on a subsidy basis. Whether the subsidies are handed out directly in the form of tax remission or as payments for the purpose of meeting interest, or as outright grants, or guaranties to the lending institutions of their mortgages at high interest rates, will make no material difference to the taxpayer. He will ultimately pay the bill for the housing subsidies which are now being set up.

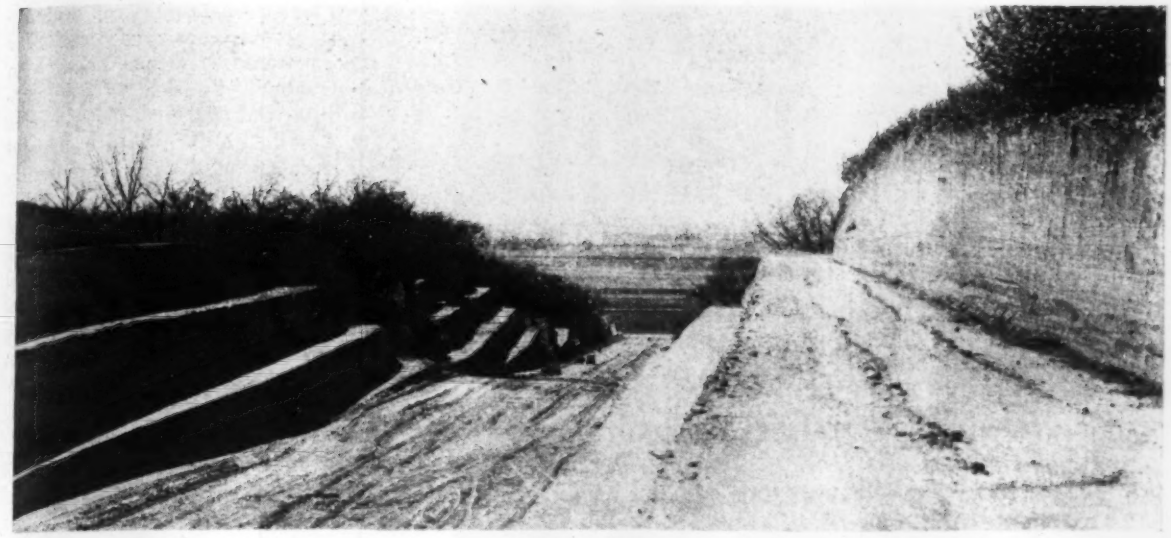

*Fig. 1. Stepped vertical face cuts carved through loess bluffs for new Iowa highway.*

# Iowa Road Carved Through Loess Bluffs

***Contents in Brief**—To prevent side erosion in deep cuts in loess soil, the Iowa state highway department called for stepped slopes with vertical walls on the relocation of Route 127 west of Magnolia. The result, in cuts up to 80 ft. deep, is the most spectacular highway in Iowa. Vertical slopes and smooth benches on the steps were formed with standard grading equipment —carrying scrapers and road graders—with no hand trimming required. In one deep cut drainage from above is taken by corrugated iron drop pipes.*

THROUGH THE LOESS BLUFFS that form the eastern ramparts of the Missouri River valley in southwestern Iowa a new highway has been carved through the wind-deposited soil as if it were so much Swiss cheese. In most spectacular fashion side slopes of cuts up to 80 ft. deep have been stepped down in 15-ft. benches with vertical walls and smooth floors that slope slightly downward away from the outer rim of each bench to keep surface waters from flowing over the vertical faces. Where the top of cut does not meet the top of bluff and side drainage cannot be provided, corrugated iron pipes, creeping up the steps like a vine, drain the watersheds behind the cut. High fills—up to 100 ft.—balance the deep cuts. In the 3-mile stretch of new road the grading amounted to 800,000 cu.yd., an indication of how hills and hollows were leveled off for the new route.

The road is a relocation of State Route 127, from Magnolia westward to the intersection of U. S. Route 75 north of Missouri Valley. The latter route lies on the valley floor; Magnolia is high in the hills. The old highway, though an important shortcut from the east to the main north-south road between Council Bluffs and Sioux City, was narrow, crooked and steep in many places. It was not surfaced, and was subject to flooding from a nearby creek. Gravel will be spread over the full 36-ft. width of the new highway, and a bituminous mat 22 ft. wide will be placed as a wearing surface.

### Loess stands vertically

The wind-deposited loess soil that forms much of the Missouri River bluffs has several peculiar characteristics. In undisturbed vertical faces it will stand for years without eroding or weathering; yet slightly sloping faces will soon be cut by water channels, and the whole face will slowly weather and slough down. When disturbed, the material breaks down into an impalpable powder. However, this same fine material, when piled into a fill, remains stable with a surprisingly small amount of surface erosion from rains.

Though cuts heretofore have never reached the depth of those on the new route, the highway department has had lots of experience with loess soil. For years the practice was to use conventional side slopes, requiring constant cleaning of ditches because of sloughing and erosion. More recently the highway engineers tried vertical-face cut slopes, but made the mistake of rounding off the top, which turned the rainfall down over the face with resulting erosion.

This time the engineers determined to design cut slopes that will stand for a long time to come without much maintenance, so the stepped side slopes as shown in Fig. 3 were adopted for both center and side hill cuts. Vertical faces, except for the bottom and top steps, were made at least 15 ft. high, and likewise the bench floors were laid out to minimum width of 15 ft. From the outer edge of the bench, floors pitch downward $\frac{1}{2}$ in. per ft. to the toe of the

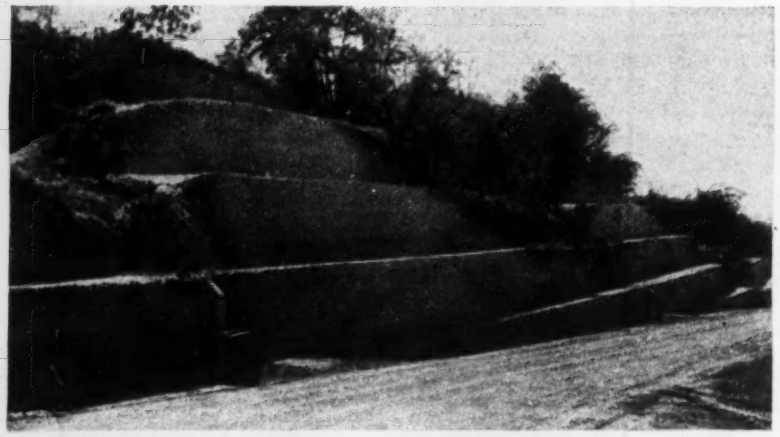

*Fig. 2. Special drains placed over the steps take care of surface water that cannot be bypassed away from the faces of the cut.*

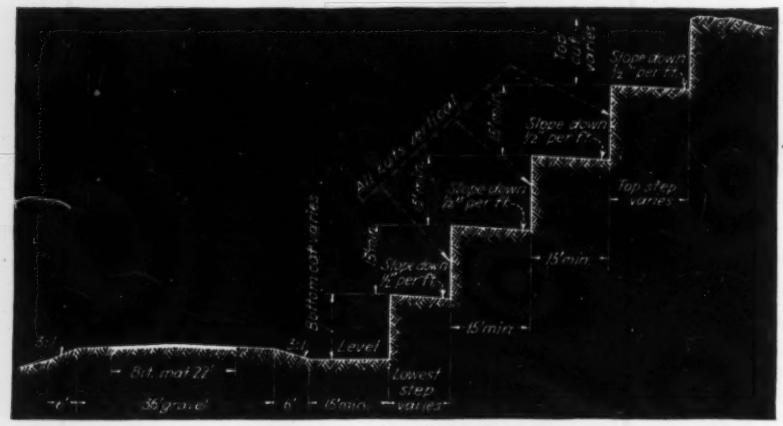


*Fig. 3. Typical cross-section of a side hill cut. Center cuts duplicate the step arrangement on both sides. Both the number of steps and the height of each drop varied with the depth of the cut.*

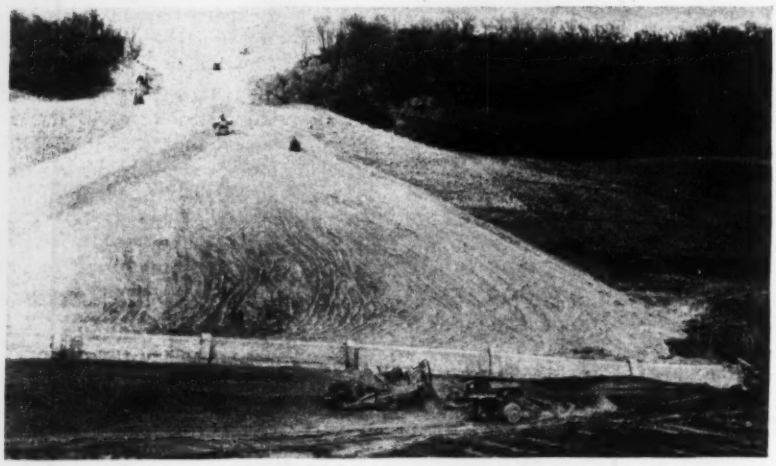

*Fig. 4. One of the large concrete culverts placed under light fills. This particular structure was built to a camber, but subsequent settlement of the supporting ground under the heavy fill put a dip at the center without cracking the concrete. Though the joints opened up, they were protected by the collars cast to one end of each section.*

next higher cut face to keep drainage away from the vertical faces. The floors are also pitched slightly in longitudinal direction to drain toward the end of the cut that provides the best natural facilities for disposal of surface waters. Each bench terminates in a feather edge at the ends.

From the behavior of the natural loess bluffs the cuts possibly would stand full height in a single vertical face. However, there is always a possibility of a slide, especially in a high freshly cut face, so the highway engineers did not wish to take a chance on possible injury to the contractor's workmen or to the traveling public. Therefore, the safer step backs were adopted.

### Excavation procedure

The entire job was excavated with standard grading equipment, and no hand trimming of the cut slopes was necessary. The grading fleet consisted of five 20-yd. carrying scrapers, hauled by diesel tractors, with three additional pusher tractors available for loading. The pushers were equipped with bulldozers, used for rough trimming of the bench floors. Cutting of the vertical slopes and final grading of the benches was by a standard motor grader.

General procedure in the cuts was to start at the top and work the full width of cut for each bench lift, trimming the bench faces and floors as the cut deepened. Cuts and fills balanced out nicely, except that two small borrowpits were necessary on the higher fills. One fill, 65 ft. high and 1,000 ft. long, contains 240,000 cu.yd., rather heavy grading for Iowa highways.

### Drainage structures

Special attention was given to drainage on the project, not only to prevent erosion of cuts and fills, but also because the high fills practically plug up many of the smaller valleys and disturb the natural drainage facilities. Most interesting is the drainage of three small watersheds above the top of one of the high side hill cuts. From the mouth of each of three small valleys, at the top of the cut, a 24-in. corrugated pipe was placed over the benches. Risers are in the open, clear of the face; horizontal sections are buried in the bench floors. The pipes are carried across the roadway, and in the fill on the opposite side are drop pipes leading to sloping pipe drains at original ground level.

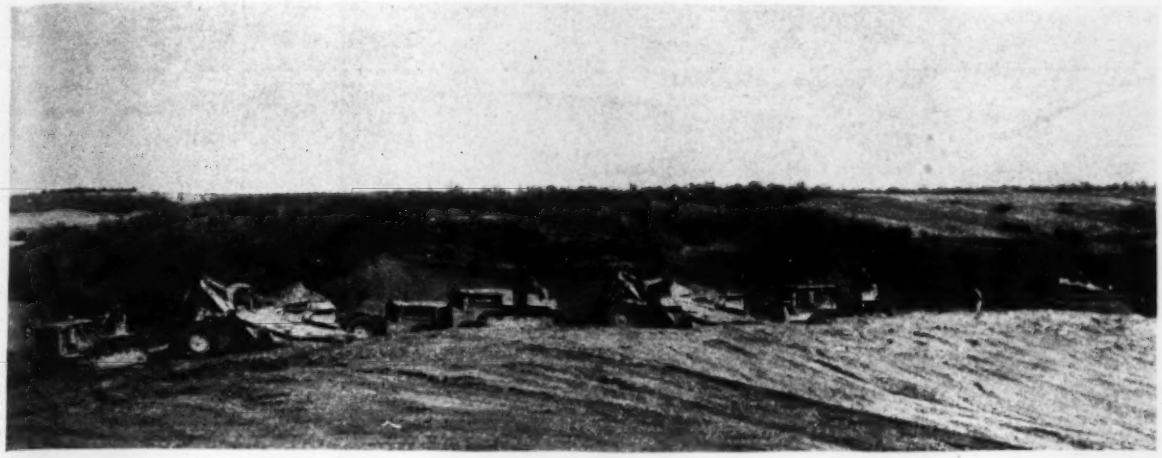

*Fig. 5. More than 800,000 cu. yd. of grading in the 3-mile length of new road was handled by five 20-yd. scraper and pusher outfits, two of which are shown in action here.*

Concrete culverts were placed under all fills. Under the highest fill, where some settlement of the original ground was expected, a 5½ x 8-ft. arch culvert was built in sections 30 ft. long, and the whole was set to a camber at the center. At each joint an integral collar was cast to one end of the section to simulate a bell-and-spigot pipe joint. When the fill was completed the ground settled even more than contemplated, changing the camber to a dip at the center. However, though the joints pulled loose they did not open beyond the collars, and the individual sections in each case resisted the change of position without cracking.

The project was under the direction of L. M. Martin, district engineer for the Iowa State Highway Commission at Council Bluffs. Fred R. White is chief engineer of the commission. The general grading contract was held by Frank Eblen, Cumberland, Iowa.

# Flexible Core for Dam in Earthquake Country

A FLEXIBLE CONCRETE COREWALL is a special feature of an earth dam designed to resist earthquake shocks and to form a new reservoir for the water supply of the city of Rangoon, in Burma. This wall, 130 ft. high and 350 ft. long on the crest of the dam, is formed of reinforced-concrete poured in panels 25 ft. long and 10 ft. high, varying in thickness from 8 ft. at the base of the dam to 4 ft. at the top. Each side has a batter of 1 in 80.

For the horizontal joints, the panels are separated by bituminous sheeting over the full thickness of the wall, and the bottom panels are connected to the foundation concrete by a tongue-and-groove joint having copper strips embedded in a bituminous material. In the top of each panel is a V-groove 9 in. deep, partly filled with asphalt in which is embedded the lower edge of a longitudinal copper strip. The bottom of each panel has a corresponding rib 3 in. deep, from which projects a similar copper strip. These two strips engage or overlap and the joint is sealed by filling the groove with asphalt. With this practical arrangement, considerable angular displacement can very easily occur without causing leakage of the joints.

For the vertical joints, which extend the full height of the wall, as the concrete for each panel was poured, precast concrete blocks were cast in each edge. Two rows of blocks in one edge formed a channel about 8x11 in., and one row of blocks in the other edge made a projecting tongue. In the tongue-and-groove joint thus formed, copper strips projected diagonally from the tongue to the sides of the groove, which was finally filled with asphalt. Steps were taken to prevent escape of the plastic filling, and pipes were provided for placing additional asphalt if it should be necessary to make up for losses. These pipes extend through a concrete wave wall 4½ ft. high, with concave face, which surmounts the wall along the upstream side of the crest.

According to the description of this dam in "The Engineer", of London, England, it is calculated that this wall can move 16 ft. out of line without permitting the escape of water through the joints. The design is based on experience with an earth dam in Japan which was distorted to S-shape in the earthquake of 1923, without breaking the puddle core wall. As suitable clay for puddle was not available in Burma, the flexible concrete wall was designed.

The dam is 126 ft. high, with 20-ft. crest, and with slopes of 1 on 3, 3½ and 4, successively from the top on the upstream side. This face is protected from erosion by a revetment of concrete slabs 6x8 ft. and 9-in. thick, poured in place. The downstream slopes of 1 on 2, 2½ and 3 are broken by three 15-ft. berms, and the toe is of broken stone faced by a low retaining wall. In each berm are drainage wells or "pillars" of broken stone, 4 ft. square and 50 ft. apart.

The Rangoon water supply project, with the Pegu-Yomas dam, was designed by Binnie, Deacon & Gourley, consulting engineers, London, England, and was carried out under the direction of A. E. Mann, chief engineer for the city of Rangoon.

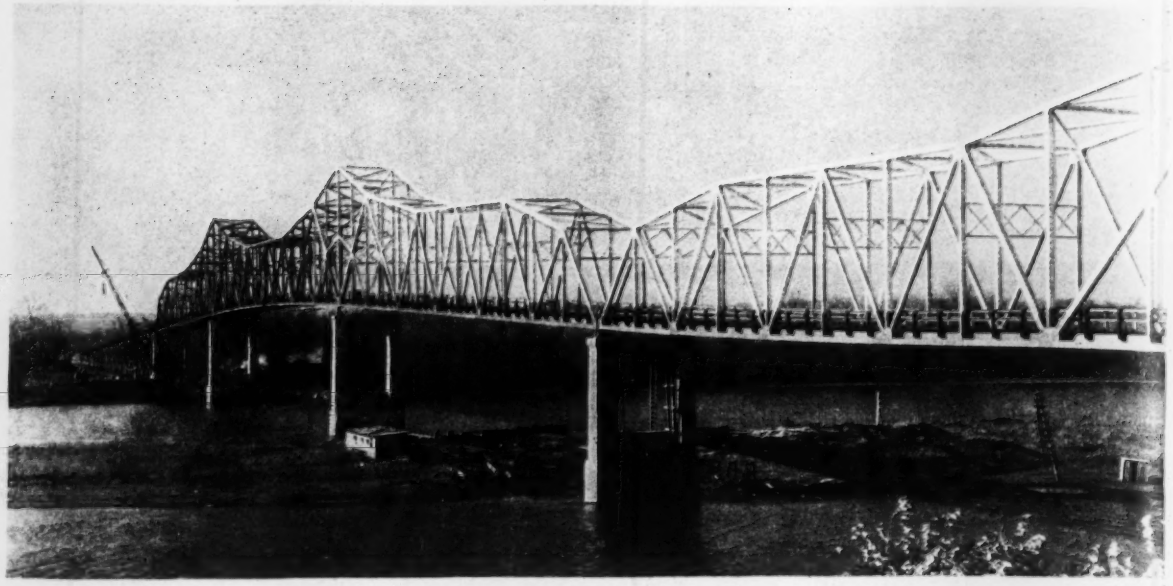

*Fig. 1. Illinois River bridge at Hennepin includes two continuous units which were adjusted to correct stress by jacking, checked by proving ring. The three-span unit is at the left; at the right is one span of the two-span unit.*

# Adjustment of Continuous Bridge Affected by Warping

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Illinois Division of Highways

**R. B. Murphy**
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Illinois Division of Highways, Springfield

***Contents in Brief**—In adjusting the reactions of two continuous bridges in Illinois on the basis of proving-ring measurement, warping of the spans was found to have large effect on stresses. High precision was attained in the measurements by careful control of temperature, moisture and wind on the rings.*

CONSTRUCTION of several continuous bridges over the Illinois River by the Division of Highways of Illinois, under a program that will extend over a period of years, made it desirable to obtain direct measurement of the end-reactions of the continuous spans, both to dispel uncertainty and to make possible any necessary adjustment for proper stress distribution. Two Morehouse proving rings of 300,000-lb. capacity each (see *ENR* March 28, 1935, p. 446 for an example of the use of such rings) were used in making the measurements. The results showed unexpectedly large influence of warping or twist of the spans, the effect of this condition on the stresses being much greater than the effect of errors in height adjustment.

Two of the bridges on the program have recently been completed. The bridge at Hennepin (Figs. 1 and 3) and that at Lacon are similar, both carrying two lanes of H-15 live load on concrete decks. Each bridge has a continuous-truss unit of three spans (324, 378 and 324 ft.), but the Hennepin Bridge also has a continuous truss of two 300-ft. spans. No sidewalk was provided at Hennepin, but at Lacon a 4-ft. walkway was provided inside the south truss.

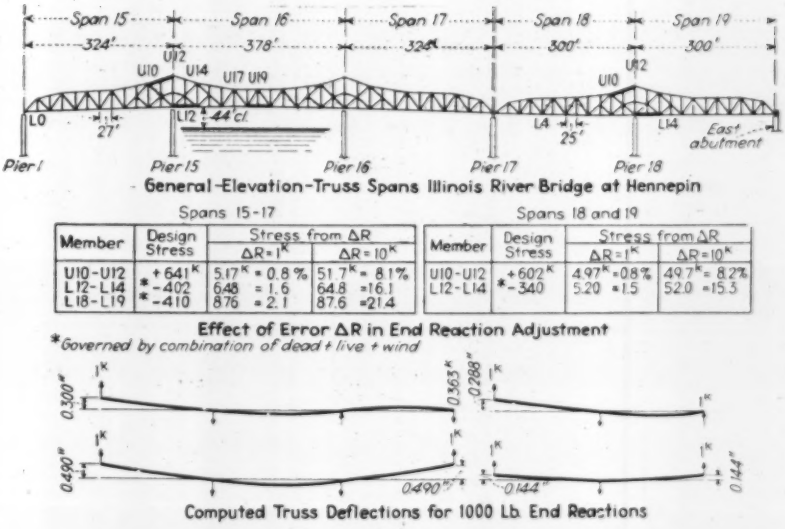
Truss sections are composed for the most part of wide-flange rolled beams; in order to avoid thin shims, 14-in. beams at 87 lb. per ft. were used throughout top and bottom chords as minimum sections, and any necessary additional area was provided by side plates shingled into the gussets. The vertical and inclined posts over the piers were made of 18-in. channels with central longitudinal diaphragms between the webs, the flanges being turned in and connected by tie plates. The fabrication was very good and no difficulties were encountered due to unequal depth or out-of-square beams. All bracing is of star section, connected at the center of the truss members. All splices are fully riveted.

The three-span unit was built by erecting its side spans on falsework and cantilevering the center span to junction at midspan, while the two-span unit was built by erecting its east span on falsework and cantilevering

the west span across the full opening with the aid of a temporary supporting bent at $L_4$. In erecting the three-span unit its ends were set $3\frac{3}{8}$ in. low, this being the theoretical jacking distance required, after closing the center panel at zero stress, to bring the structure to proper continuous action. All reaction adjustment was done before placing the concrete deck.

Errors in reactions would affect stresses and deflections as tabulated in Fig. 3. It was considered that the allowable error in the reaction should not exceed 1,000 lb. or about 1 per cent.

A check on the final dead load stresses was obtained by strain-gage measurements on the center lower-chord sections of Span 16 and the lower chords adjacent to the center support of the two-span unit. Initial or zero readings had been taken on these members before erection; the final readings were taken after the end bearings had been set in final position prior to placing the concrete deck. All such readings were taken at night or on cloudy days to avoid temperature errors. The average stresses computed from these readings checked the calculated design stresses within the limits of experimental error. A 10-in. Whittemore strain gage was used in this work. Gage holes were protected when not in use by a coating of "no oxide" grease, to avoid errors of measurement due to displacement of the contact points of gage by rust coatings.




General-Elevation-Truss Spans Illinois River Bridge at Hennepin

Spans 15-17

| Member | Design Stress | Stress from ΔR: ΔR=1K | Stress from ΔR: ΔR=10K |
|---|---|---|---|
| U10-U12 | +641K | 5.17K = 0.8% | 51.7K = 8.1% |
| L12-L14 | *-402 | 6.48 = 1.6 | 64.8 = 16.1 |
| L18-L19 | *-410 | 8.76 = 2.1 | 87.6 = 21.4 |

Spans 18 and 19

| Member | Design Stress | Stress from ΔR: ΔR=1K | Stress from ΔR: ΔR=10K |
|---|---|---|---|
| U10-U12 | +602K | 4.97K = 0.8% | 49.7K = 8.2% |
| L12-L14 | *-340 | 5.20 = 1.5 | 52.0 = 15.3 |

Effect of Error ΔR in End Reaction Adjustment

*Governed by combination of dead + live + wind




Computed Truss Deflections for 1000 Lb. End Reactions

***Fig. 3. The two continuous units of Hennepin Bridge were adjusted to desired stress distribution and deflection by considering the effect of errors in the reactions.***

The trusses were found to be somewhat stiffer than computed by the conventional method of neglecting the effect of splices and gussets on the cross-section. Little difficulty was encountered in adjusting the three-span unit. In weighing the reactions of the two-span unit at Pier 18, however, one truss was found to have a reaction about 13,000 lb. greater than the other. It seemed evident from this difference that one truss had been raised slightly out of level with the other in jacking at the ends, and investigation proved that such was the case.

Readings were taken at the abutment and also at PIER 18 with the weighed end out of level by various amounts. The results of these data were analyzed to determine the increments necessary to add or subtract from each reaction for a given variation in the elevations of the two trusses at one end.

The two right-hand curves in Fig. 4 show the measured reactions for the two-span unit for a given lift above the initial position with the ends of the two trusses level, while the left-hand curve shows the measured reaction increment due to raising one truss above the other at the measured end by a given amount. This warping increment is further illustrated by the deflection and tilt values shown in Fig. 5.

It will be noted that the change in reaction due to warping by a given amount is *over ten times as much* as that caused by raising both trusses the same amount. Approximate analysis showed that this change in reaction, being due to lateral stiffness of the portals, sway frames and floorbeams, represents a change in stress throughout the spans and that it is fully as important that such warp be removed as it is that correct elevations of bearings be reached. It also illustrates what may occur in a struc-

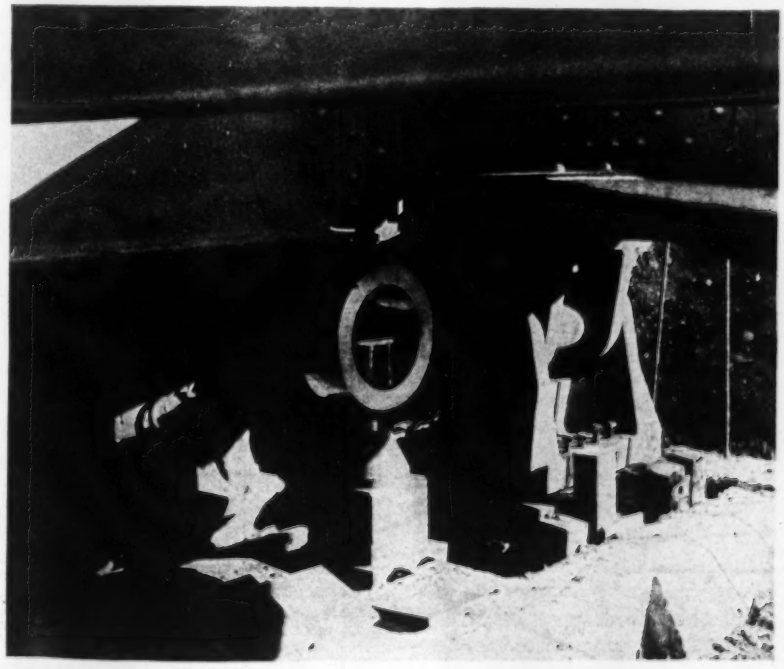


***Fig. 2. Checking the reaction adjustment of a continuous-truss unit of Hennepin Bridge by proving ring.***

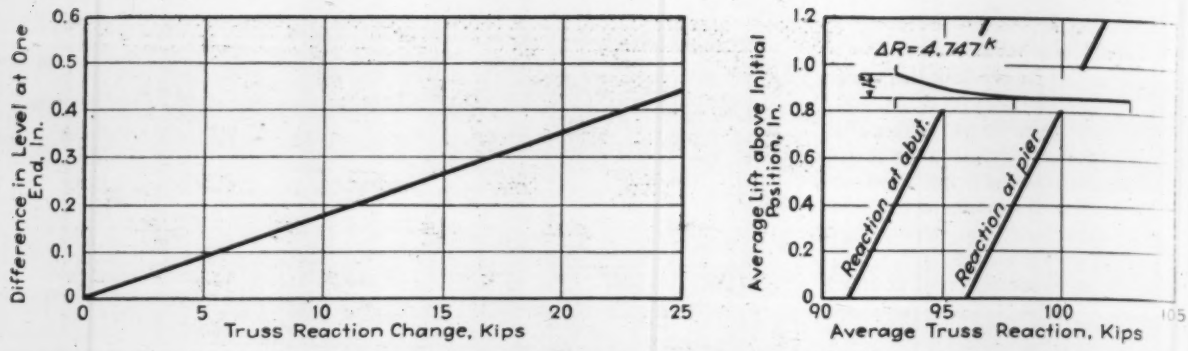



***Fig. 4. How variation in end lift affected the truss reactions of spans 18 and 19. Note in the chart at the right that pier reaction is heavier than abutment reaction because of the weight of expansion joints and other special details. The left-hand chart shows truss reaction increment due to difference in level at one end. The plotted reaction change is one half the difference in reaction changes of the opposite trusses.***

ture as the result of movement of the falsework at different stages of riveting and consequent difference in shape of the two trusses.

#### Precision of the measurements

The Bureau of Standards calibration curves for the proving rings show that the maximum error found in calibration corresponds to about 0.3 of a dial division, or about 130 lb. In the field work there were two sources of possible error from temperature: the modulus of elasticity of the steel is affected by temperature, and difference in temperature between the vibrating reed and the ring will affect the reading. To minimize these, all weighing was done at night to insure constant temperature of the top and bottom chords, and the rings were protected by a housing of canvas and plywood, though a certain amount of draft could not be avoided.

In order to eliminate personal-equation errors, independent readings were taken by two different operators at each ring during each loading. It is believed that the maximum instrumental error from all causes did not exceed 500 lb. and was probably less. Larger and more easily made errors occur in level readings in checking the elevation of one truss against the other. These errors were eliminated later in weighing the Lacon Bridge, where elevations were not measured by the level but by a sliding steel gage at each end bearing, heights being measured by a rule from the original position of the truss before jacking.

At each weighing operation, each observer took five readings for each measurement. Zero readings were taken before loading the ring and again after removing the load. The operators exchanged places after weighing, and reweighed with the ends at the same elevation, the results agreeing very closely. In addition to this check on operators, the rings themselves were interchanged when taking measurements at Pier 17. Again the results were in close agreement, showing the rings to be very accurate under field conditions.

After the trusses had been weighed as described, each end was adjusted vertically to equal truss reactions. The three-span unit was adjusted first, and the two-span unit then adjusted to meet the grade of Span 17 at Pier 17 by rotating about Pier 18. The theoretical weights had been carefully calculated from the shop drawings and due allowance made for extra planking and other loads present on the bridge at the time of weighing.

Weighing operations conducted later at Lacon gave results similar to those obtained at Hennepin. Here also a large effect of warping the end of one truss above the other was observed, though it was only 80 per cent as large as at Hennepin. This was as expected, since the width between trusses at Lacon is 3½ ft. greater while the portal and sway bracing are similar, and the bridge therefore opposes slightly lower rigidity to any warping tendency that may arise.

#### Engineers and contractors

The Hennepin Bridge, completed last September, was fabricated by the Chicago plant of the Bethlehem Steel Co. and erected by the Wisconsin Bridge & Iron Co. The design was made under the direction of Ernst Lieberman, chief highway engineer, and George F. Burch, bridge engineer, Illinois Division of Highways. G. A. Somerville, district engineer at Ottawa, L. T. Wyly, consulting engineer on construction, and J. E. Raffensperger, resident engineer, supervised construction for the state.

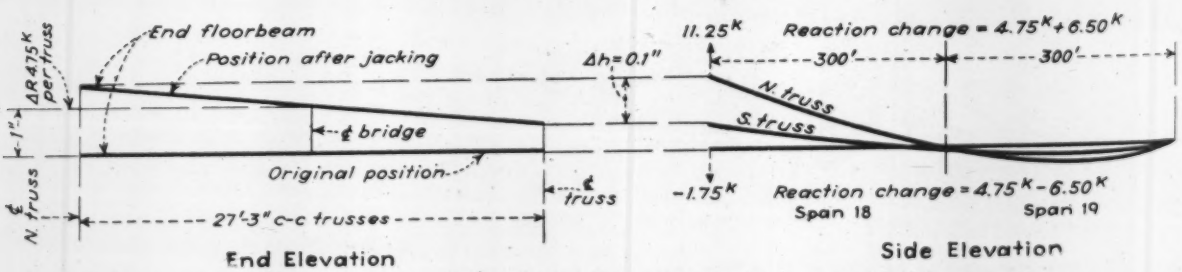



***Fig. 5. Change in end reactions due to warping at end of spans 18-19 of Hennepin Bridge is substantial.***

# Doing Something About Accidents

**Roy A. MacGregor**

Executive Secretary
Constructors Ass'n. of Western Pennsylvania, Pittsburgh, Pa.

***Contents in Brief**—When members of the Constructors Association of Western Pennsylvania complained that compensation insurance premium rates were too high, their clear-thinking Scotch secretary told them the only way to reduce the rates was to reduce accidents and their resulting costs. That started an accident prevention campaign among the members, not one of those flash affairs, but a sound, continuous program. In this article Roy MacGregor points out why premium rates are high in construction, what should be done about the situation, and what is being done about it in western Pennsylvania.*

"TELL 'EM, MAC, that workmen's compensation insurance rates are too high and should be cut down."

This remark started what has developed into an active, continuous effort on the part of the Constructors Association of Western Pennsylvania to reduce accidents on the jobs of its members, working toward a reduction in insurance premiums.

The remark showed that the man who made it did not fully realize the reasons for the high costs of this insurance, and also did not appreciate that he, personally, had a certain amount of control over his own compensation costs by showing an interest in and taking measures to prevent accidents on his work. The construction industry as a whole is made up of many contractors in the same position. In fact, the entire construction industry, (comparing its compensation insurance rates with the rates paid by other industries) definitely shows a lack of interest and appreciation of the value of accident prevention.

We have only to look at the steel industry to see the possibilities of accident prevention through organized effort. Steel, with hazards greater than those in construction, pays less than one-third the workmen's compensation premium rates charged against construction. Steel proudly boasts of a decrease of 90 per cent in accident costs in 30 years. Construction can do as well in much less time if contractors apply themselves, for they have the advantage of safety experience and an enlightened public opinion not existing in the early days of steel's efforts in accident prevention.

In the continuous campaign of the Pennsylvania contractors, attention is directed to the origin of the cost of insurance. Analysis of benefits paid out for construction accidents in this area over a period of three years shows that 52.8 per cent of the total went for accidents arising from only 25 sources or causes. Further study revealed that eight of these 25, or one-third, involved truck operation. Thus, elimination of all accidents around trucks would decrease compensation insurance costs about 13 per cent, while elimination of all accidents arising from the 25 principal causes would cut the costs in half.

Here is a definite target to shoot at, and our contractors are concentrating on these comparatively few high-rate accident causes.

Also in our accident prevention work much stress is laid on the advantage a contractor with a good accident record has in bidding against one with a poor record. In this area a contractor with a low accident record pays only 60 per cent of the manual premium rate, compared with 150 per cent paid by contractors with high accident frequency. A concrete example is shown by the Pennsylvania Turnpike work, where, under an average manual rate of $10 per $100 payroll, some contractors are paying only $6, while others with poor accident records are paying $15. This means that, with the payroll amounting to one-third of the total bid price, the contractors with low accident records have an advantage of $3,000 on every $100,000 bid.

While the subject is being approached here from a purely economic angle, the humanitarian side is not ignored. Every effort is being made to stimulate interest among the workmen in eliminating the results of carelessness.

The accident prevention work in western Pennsylvania is carried out by a committee that includes four full-time accident prevention engineers for their respective companies: S. E. Anderson, Harrison Construction Co.; G. O. Griffen, Dravo Corp.; J. E. Jackman, McCrady-Rogers Co., and Norman E. Wellings, Booth & Flinn Co. These men work with C. R. Carter, vice-president, Ferguson & Edmondson Co., chairman, and John E. Jackson, president, Pittsburgh-Des Moines Steel Co., as the other member.

This committee has developed active cooperation with the engineers of the leading insurance companies in the district, as well as with the interested division of the State Department of Labor and Industry. Meetings of these three groups are held frequently and every effort is made to make contractors realize the importance of accident prevention in reducing compensation insurance rates.

***Safety device increases efficiency.***

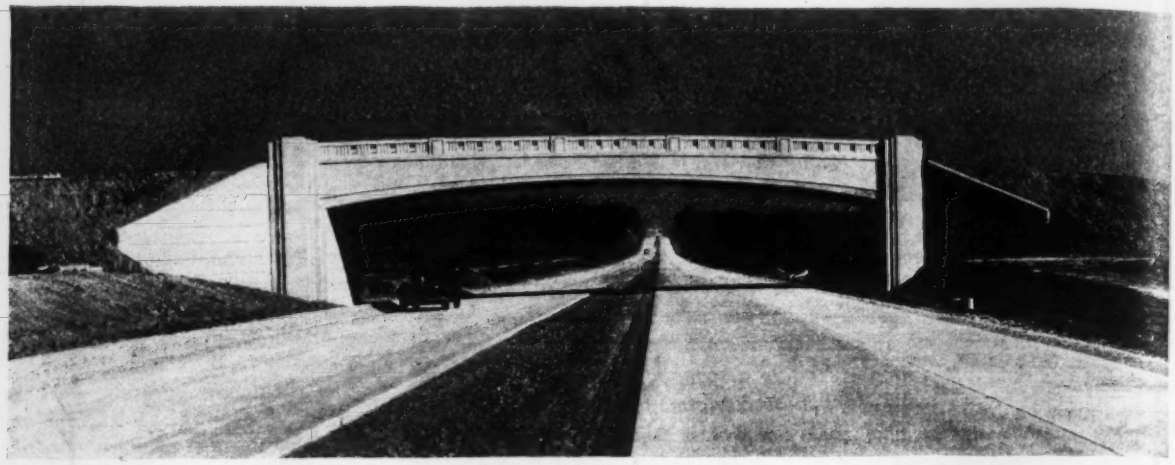


*Fig. 1. Typical concrete rigid frame bridge over the Turnpike.*

# Bridging the Pennsylvania Turnpike

**R. F. Graef**

Chief of Bridges, Pennsylvania Turnpike Commission
Harrisburg, Pa.

***Contents in Brief**—On the 160-mile Turnpike 307 grade separation and drainage structures were required. They were designed and built on a rush schedule which required simplicity yet they utilize modern architecture and take account of best modern design practices. In this article, the man responsible for the structures describes them, their design, and their cost.*

THE CONSTRUCTION of America's first superhighway has involved a bridge program representing a total construction cost of about $7,600,000 for 307 bridges and culverts. It was necessary to turn out drawings for bidding purposes for nearly 90 per cent of these structures within a period of seven months.

Despite this rush work particular consideration has been given to appearance, each structure being studied with the view to obtaining the best architectural treatment without undue expenditure. In keeping with the superhighway idea, all design has a modern trend. No truss spans have been used over the Turnpike despite the fact that in some cases this type would have given a slightly more economical solution than that used.

Plate girder structures have been treated by extending end pylons on the abutments up beyond the ends of the girders, with the pylons so located that the concrete can be returned around the ends of the girders to form end posts. T-beam overheads have been detailed so that the expansion joints in the deck are hidden behind posts at the abutments and above the piers. Rigid frames of two general architectural types have been used. The first of these emphasizes end pylons on the abutments, and the deck appears as a restrained beam with curved soffit. In the other type, the rigid frame has been emphasized by the use of wings battered outward and a plain surface on the exposed portion of the frame. Parapets of structures at Turnpike grade were given considerable attention, and an attempt has been made to subdue those on short span structures where width of roadway is much greater than length of parapet. All parapets have been designed to obtain the maximum of simplicity.

Nearly all structures carrying the Turnpike have roadway widths of 70 ft. curb to curb. This is made up of two 24-ft. traffic lanes with 10-ft. middle strip and 6-ft. water tables. Two longer structures are 56 ft. curb to curb, having two 24-ft. traffic lanes, a 4-ft. raised division strip and 2-ft. water tables; another bridge has the same arrangement plus an accelerating lane from one of the interchanges. Design loading for all structures carrying the Turnpike is a modified H-20, all trucks being

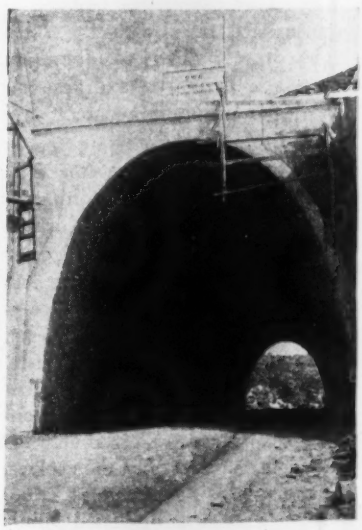


*Fig. 2. Barrel arch, 36½-ft. span, 42-ft. rise, 278 ft. long, will carry Turnpike on a 40-ft. fill over a state route.*

taken as 20-ton instead of the usual reduction to 15-ton trucks in the trains following and preceding the truck and semi-trailer load. A reduction of 20 per cent is taken in consideration of improbability of having maximum load on four lanes simultaneously.

The design loading used for all structures carrying intersecting roads over the Turnpike is that specified by the Pennsylvania Department of Highways and consisting of a continuous train of 20-ton trucks for each 10-ft. lane with all axles spaced 14 feet center to center. Impact allowance for all structures is from the formula $I = \frac{75}{L + 200}$. Specifications are practically identical with those of the A.A.S.H.O. Double curbs are used, of such shape that the fenders of a car striking the lower curb will not hit the upper curb or parapet, nor will the overhang of a truck or bus hitting this curb foul the parapet. The use of double curbs permitted design for high strength without greatly increasing the section. All but one structure uses concrete curbs; all but two, concrete parapets.

In general, foundations encountered in the construction of these bridges were good, as is evidenced by the fact that only 34,000 ft. of piles (including test piles) were required for the entire project. Material encountered ranged from compact clay to solid sandstone; fortunately rock was encountered a very short distance below original ground at all larger structures. Coal deposits presented some special foundation problems and in one case required excavation to a depth of more than 40 ft. and subsequent construction of high piers, founded on shale, to carry an intersecting state highway over the Turnpike.

### Grade separations

In order to exclude all highway grade crossings along the Turnpike, it has been necessary to build 75 structures at state highways, 60 at township roads and 12 for private lanes, farm crossings, etc. In addition, 11 structures are required to separate grades at interchanges, 5 at railroad crossings and 1 at a trolley crossing. One of the structures required for railroad grade separation also crosses a stream, and each of two others cross a stream and highway in addition to the railroad. The total number of structures required for grade separation purposes is 163.

Although studies revealed that twin-span construction is the most economical for grade separations, it was considered that the use of piers in the middle strip is undesirable and it was resorted to only in those cases where the use of single-span construction would result in excessive cost. Of the twin-span structures studied, the reinforced concrete rigid frame proved to be the cheapest, followed in order by reinforced concrete T-beams and steel I-beams.

The studies revealed the solid deck reinforced concrete rigid frame to be the most economical single-span structure suitable for carrying intersecting roads over the Turnpike. This type has been selected for intersections where foundations are unyielding in character and skew does not exceed 30 deg. The normal clear span of all these structures is 78 ft. In order to maintain a minimum vertical clearance of 14 ft. at both the edge of pavement and 5 ft. out on the shoulder, it was necessary to use leg heights ranging up to 29 ft. Roadway widths vary from 12 ft. at one private crossing to 35 ft. plus a 4-ft. sidewalk at a state highway. One intersecting road carried on a rigid frame has a superelevation varying from 0 to ¾ in. per ft. across the span. Making the deck of this structure ribbed proved to be a successful means for relieving the intrados of the warped appearance which would have resulted if a solid deck had been used.

The program involved the construction of 53 rigid frames at unusually high speed; most of the contractors engaged on the Turnpike construction had built few, if any, rigid frame structures prior to this undertaking and it was recognized that inspection personnel with previous experience in this type of construction could not be secured in sufficient numbers to handle properly this amount of work. Because of these conditions, it was considered to be in the interests of sound engineering to establish conservative limitations upon the use of this comparatively new type of structure, and not

*Fig. 3. The Turnpike crosses the Lincoln Highway on a sharply skewed plate girder bridge near the Midway station west of Bedford.*

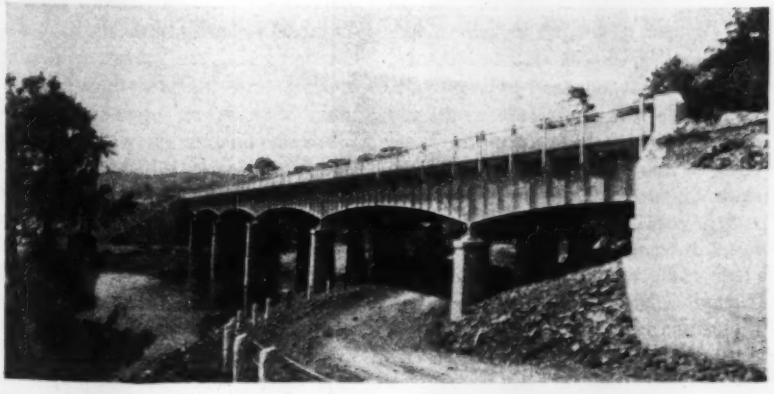


*Fig. 4. Four 96-ft. spans and two 48-ft. end spans make up this continuous plate girder on a 50-deg. skew crossing Dunnings Creek east of Bedford.*

because it is impractical to design rigid frame structures for use on yielding foundations or for skews greater than 30 deg.

#### Skew rigid forms

In spite of these considerations, it was maintained by some that the limitations imposed were not sufficiently conservative, based on the contention that 30-deg. skew is too severe with the roadway widths used (20 to 22 ft.). This argument was founded on a fallacious concept regarding the distribution of stresses in skewed frames; nevertheless, in order to refute this erroneous contention, it was found necessary to test one of these frames before we could proceed with the construction of the remaining structures of this type and proportion. The frame tested had a normal clear span of 78 ft., height of leg 16 ft. 4 in. (hinge to intrados springing), overall width of 25 ft. 3 in., crown thickness of 3 ft. and springing thickness of 6 ft. Measurements taken at the time of striking underpinning centers revealed an average deflection of $\frac{7}{16}$ in. at centerline of the span. This value checked the computed dead load deflection within 10 per cent. The test live-load was applied in two phases, the first of which consisted of rolling across the span two parallel trains of trucks spaced approximately 24 ft. center to center, each weighing about 13 tons loaded. The second loading consisted of a single 40-ton shovel. Deflections occurring during each of these tests were well within the computed values. End rotation of the deck was of such magnitude as to be represented by the difference in ease with which a knife blade could be inserted in the top of the joint between frame and wing walls with and without the load of the span. Following this test, all objections to construction of 30-deg. skew rigid frames were eliminated.

Single-span, solid-deck, reinforced concrete rigid frames have been used also for those grade separations at interchanges where the Turnpike is carried over the ramp or intersecting road. These vary in span from 38 ft. to 71 ft. 6 in. and in skew from 0 to 29 deg. and have roadway widths of from 56 to 105 ft. Principal quantities for the 53 rigid frames used on the Turnpike are about 43,750 cu.yd. of concrete, 7,150,000 lb. of reinforcing and 16,500 cu.yd. of excavation. Total cost is about $1,275,000 for 139,660 sq.ft. of bridge, or $9.13 per sq.ft.

In some cases, where the limitations placed on rigid frame construction eliminated its use, twin-span T-beam structures with skews from 0 to 45 deg. are used to carry intersecting roads over the Turnpike. There are 20 structures of this type requiring 15,200 cu.yd. of concrete, 1,450,000 lb. of reinforcing and 11,000 cu.yd. of excavation, at a cost of about $386,450 for 44,420 sq.ft. or $8.70 per sq.ft. of bridge.

#### Plate girder structures

In all other cases where foundation conditions or skew are such as to preclude the use of rigid frames, plate girders have been used for overhead crossings. These are all of the through type and are single-span for all skews up to 50 deg. and twin-span for two intersections where the skew is 54 deg. One intersection having a skew of 69 deg. necessitated the use of a special three-span plate girder structure. This structure has been laid out with square-off spans and with all floorbeams normal to girders. Each line of the two through girders has two spans of 116 ft. and one of 81 ft. Use of continuous girders was not practical because of unsatisfactory foundation conditions. Abutments and piers have been so laid out as to make the appearance of the structure from the Turnpike as nearly as possible like that of a two-span structure and curtain walls have been used to eliminate such confusion to traffic as might result from the unbalanced layout.

There are 23 plate girder structures carrying intersecting roads over the Turnpike. Single spans vary from 80 ft. 6 in. to 132 ft. and each span of the twin-span girders is 71 ft. 3 in. Roadway widths vary from 12 to 46 ft. Principal quantities in these structures are 4,975,450 lb. of structural steel, 23,750 cu.yd. of concrete, 1,974,000 lb. of reinforcing and 12,700 cu.yd. of excavation. Total cost is about $853,100 for 82,920 sq.ft. or $10.29 per sq.ft. of bridge.

Structures carrying the Turnpike *over* intersecting roads require less clear span than those spanning the Turnpike. Similarity of design is not a consideration as various roads are crossed. For usual crossings, 44 simple span T-beam bridges, 7 slab type, 3 plate girder and one I-beam span have been use. Some intersections occur where the distance, grade to grade of roadways is considerably greater than the minimum, and the use of structures with decks at Turnpike grade would result in abutments of excessive height. Studies indicate that for these cases the barrel arch is by far the most economical. The most notable structure of the 7 of this type is illustrated in Fig. 2.

#### Drainage structures

Drainage structures are for the most part small and presented no unusual problems. It was necessary to provide 143 culverts and bridges for streams under the Turnpike and adjacent roads affected by Turnpike construction. Of chief interest are the reinforced concrete barrel arches used wherever the distance from streambed to grade permits. These vary in size from 6-ft.-span culverts to the structure over Clear Creek in Bedford County, which has two spans of 52 ft., a length of 305 ft. and a fill of 70 ft. over the crown. This structure contains over 8,000 cu.yd. of concrete. There are two other barrel arches of two 52-ft. spans but they are shorter.

A few concrete box culverts and several I-beam spans have been used. For other cases, reinforced concrete slabs have been used for spans up to 16 ft. and reinforced concrete T-beams for spans ranging up to 45 ft. All are simply supported except a three-span continuous structure which has a middle span of 54 ft. and side spans of 25 ft.

#### Larger bridges

Of the larger structures, the most important is that over Little Sewickley Creek, a state highway and tracks of the Pennsylvania Railroad near New Stanton. This structure has a total length of 600 ft. with an average distance from foundation to grade of 49 ft. The Turnpike is on a 2½-deg. curve crossing the bridge. Abutments and piers are radial to the curve. The main span is an open-spandrel reinforced concrete arch of three ribs, 9 ft. 6 in. wide with 170-ft. clear span, 37-ft. rise, 2 ft. 9-in. crown thickness and 5-ft. 10-in. springing thickness. Flanking the arch span on each end are two spans of 83 ft. and one of 43 ft. c. to c. of supports, with the shorter spans at the extreme ends. The middle span of each of these groups is a rigid frame, while the spans at either end are concrete T-beams restrained at the rigid frame and simply

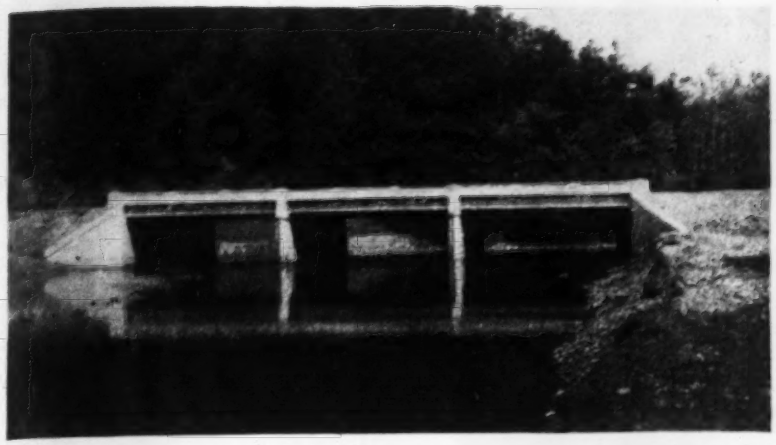


*Fig. 5. Three-span concrete T-beam drainage structure in Bedford county.*

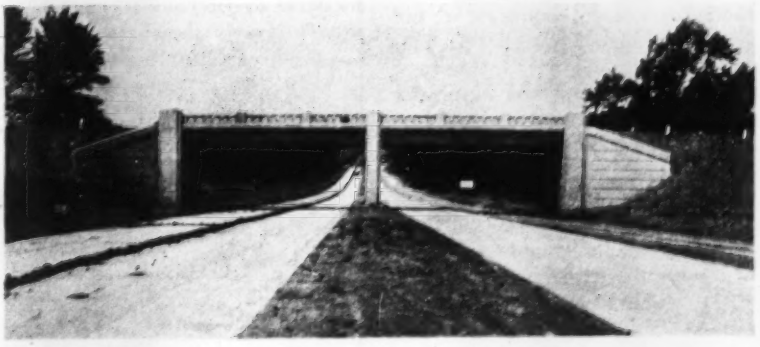


*Fig. 6. Typical twin-span T-beam overhead. Use of a center pier is limited to seven short sections of the Turnpike.*

supported at the ends away from the frame. The rigid frames in the approach groups are of ribbed type, and the adjacent spans are T-beams. Width of all ribs and beams is 1 ft. 10 in. and clear distance between them 4 ft. 2 in. All are 4 ft. deep at the centerline of each span and at all simple supports, and 8 ft. deep at each face of the rigid frame legs. In addition to the normal roadway width of 56 ft., this structure carries an 8-ft.-wide accelerating lane of an adjacent interchange. The utilization of this arrangement of rigid frames and restrained beams eliminated the high temperature and shrinkage stresses which would have occurred with three-span rigid-frame construction and gave dead and live load moments in the end spans not much higher than would have occurred with that type of construction.

Two 3-span continuous plate-girder structures have been used at skew crossings. Both have middle spans of 110 ft.; one has end spans of 65 ft. each and the other 76 ft. Both are of deck type, having four lines of parallel flange girders with the two lines of stringers nearest the centerline of roadway and those at the fascia carried on brackets.

Parsons, Klapp, Brinckerhoff & Douglas, New York City, designed the bridge over Dunnings Creek, east of Bedford, a six-span continuous plate girder structure with 50-deg. skew. End spans are 48 ft. and the four interior spans 96 ft. each. Four lines of curved bottom chord girders are used, with fascia and centerline stringers bracketed. An expansion joint runs the full length of the deck at the centerline of the roadway. Concrete curbs and steel pipe railings outline the 56-ft. roadway.

Also near Bedford, where the Turnpike crosses the Raystown Branch of the Juniata River, Modjeski & Masters, Harrisburg, Penna., designed a structure to cross the stream, the tracks of the Pennsylvania Railroad and a township road. This bridge is on a 2-deg. curve and abutments and piers are radial. The section of the structure over the stream consists of two parallel lines of curved bottom flange girders continuous over three spans. The interior span is 125 ft. and exterior spans, 100 ft. At the east end, six spans of continuous I-beam stringers in 2 three-span groups, with spans ranging from 40 to 50 ft., are used to cross the railroad and township road. Roadway width is 56 ft., railing and curbs are steel.

A continuous I-beam stringer bridge over Conodoquinet Creek in Cumberland County, consisting of three 69-ft. spans, completes the list of larger structures. Its cost of $5.25 per sq.ft. of bridge is lowest for the larger structures, which range up to $8.05 per sq.ft. in cost.

Three hundred five bridges and culverts were designed by the Turnpike bridge division. On January 1, 1939, only 34 structures had been designed. By September 1, 1939, all of the remaining structures had been designed and the drawings completed, except 12, included in later paving contracts. The number of designers employed in the bridge division during this period ranged from 7 to 20, and the total personnel, including clerical, from 12 to 37. To accomplish this in the available time it was necessary to use unchecked or referenced drawings for bidding purposes. The referenced drawings were of structures designed for previous contracts which were similar enough in character to the ones for which prices were desired to enable bidders to determine unit prices. Quantities for the actual structures, basic data and anticipated dates of furnishing completed drawings were supplied with the referenced drawings. This device was employed in order to provide six to eight weeks' extension of time to the limited personnel for the completion of the drawings. Although this extension of time may seem small, it was most valuable on a project involving almost impossible assignments in the preparation of designs and plans. The time allowed for completion of construction was so short as to make mandatory the advertising for bids on each contract on the scheduled date, so the contractor could make preliminary preparations and move in.

Willing cooperation of the designers and draftsmen, under immediate direction of H. E. Kunsch, assistant bridge engineer, made the rapid pace and successful accomplishment possible.

# Driving 85 Miles of Tunnel

***Contents in Brief—On the 85 miles of tunnel for New York's new water supply the contractors have raised tunnel driving to record standards of speed, efficiency and safety. Here new ideas are found in drilling and blasting procedure, drill carriages, car changers, and invert clean-up. Previous articles (April 11, p. 513; April 25, p. 584; May 9, p. 656; June 6, p. 797, and July 18, p. 73) described the function and design of the aqueduct.***

IN DRIVING the greatest tunnel project ever attempted, the 85-mile Delaware River Aqueduct for New York City's water supply, ten contractors on eleven contract sections have brought tunnel driving to its highest perfection and standards of performance. Tunneling is being carried out with the scheduled precision equal to high-class railroad operations; every minute counts, and timing of the blasts on some sections doesn't vary more than five minutes from day to day. Every advantage is being taken of the experience and developments of the more recent tunnel projects, particularly the Colorado River Aqueduct, which, coupled with new ideas and new types of equipment, open a new chapter in the technique of tunnel driving.

***Fig. 1. Location of shafts on the aqueduct. From Lackawack to Hill View Reservoir is 85 miles.***

Each of the eleven contract sections is of interest; each is contributing something to the art of tunneling. However, because space limitations preclude a detailed description of construction operations on each section, the driving procedure will be described for the whole project on a functional basis. This article on construction of the aqueduct covers drilling and blasting, mucking and timbering. Other functional features, such as hauling, hoisting, ventilation, pumping, concrete lining and driving through bad ground, will be described in subsequent issues.

### Project and contracts

The aqueduct project has been described in previous articles in this series. A total of 83.8 miles of tunnel was awarded in eleven contract sections. Shaft No. 1 and the first mile of tunnel at the Rondout Reservoir intake are a part of the contract for Merriman Dam; shaft sinking is under way but major tunneling on this section has not yet been started. Ten contractors took the other eleven tunnel sections for a total of $140,109,135. Contract sections vary in length from 5.1 to 14.2 miles; in amount from $10,097,135 to $21,333,333. The tunnel is being driven from 24 shafts from 300 to 1,550 ft. deep, all sunk under previous contracts except the six shafts No. 11 to 16, which were part of the tunnel contracts.

Contract data are shown in the accompanying table. Contracts 306 and 321 include considerable surface work, such as connections to adjacent reservoirs and construction of gate chambers, aerators, and appurtenant structures. Other contracts involve installation of control works and drainage stations in the shafts. Shafts 9, 10, 17, 18 and 19 are double shafts; they include separate uptake and downtake shafts at each location. Permanent Shaft 13 is offset from the tunnel line and requires installation of considerable pumping equipment, so Seaboard Construction Co. sank a temporary shaft on line to expedite construction operations.

In most cases headings are driven both ways from the bottom of the shaft. One-way headings are being driven north from Shaft 1A North (the outlet at Hill View Reservoir), from Shaft 19 downtake and uptake, from Shaft 17 downtake and uptake and south from Shaft 10 uptake. Because of extensive surface construction at Shaft 18, Associated Contractors, Inc., is driving the adjoining sections of tunnel from shafts 17 and 19. For the same reason, Frazier-Davis temporarily deepened Shaft 10 uptake 109 ft. to correspond to the depth of 10 downtake and are driving south from this shaft; the heading from 9 downtake, at a higher level, will hole through into 10 uptake. The two shafts at No. 9 are about the same level, and Frazier-Davis cut through the distance of about 50 ft. between them and thus was able to use one headframe installation for driving both ways.

The tunnel is of circular section in three sizes. From the end of the tunnel contract section north of Shaft 2 to Shaft 9 uptake are 43.1 miles of 13½-ft. finished diameter tunnel, requiring an excavated section of about 18 ft. Between Shafts 9 downtake and 18 uptake the tunnel is 15 ft. finished, and about 20 ft. excavated diameter, 27.1 miles long. For the 13.6 miles

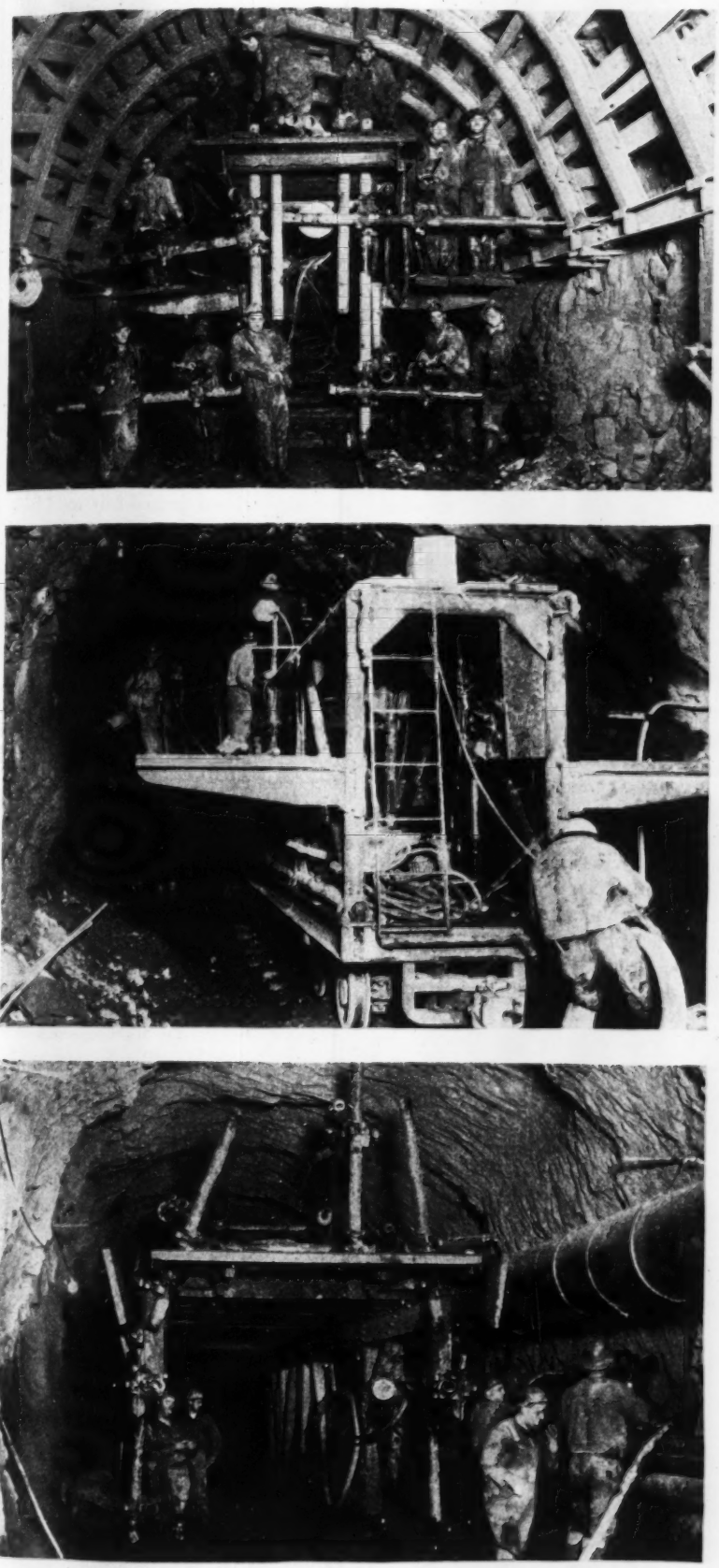


Fig. 2. *Three types of drill jumbos: top, steel frame drill carriage on muck track, Rosoff; center, pipe frame jumbo (frame serves as air manifold) on muck track, Pleasantville Constructors; bottom, steel frame jumbo on wide track, Walsh.*

from Shaft 18 downtake to the outlet at Hill View, the tunnel is 19½ ft. finished, and about 24 ft. excavated diameter. Excavation, in general, has been completed south of Shaft 18 and is rapidly nearing completion between Shafts 10 and 18.

### Procedure in common

Naturally details of driving operations, equipment and plant vary widely among the ten contractors. However, there are several methods and plant items common to all.

The New York state labor law requires adequate change houses for the workmen, but most of the contractors went beyond minimum requirements and built quarters for the crew that are models of cleanliness, comfort and sanitation. Automatic oil heat, mechanical ventilation, concrete floors, individual steel lockers and adequate shower and sanitary facilities are features of these quarters.

Compressor plants vary from 3,000 to 6,000 cfm capacity at each shaft, made up of units ranging from 550 to 3,000 cfm in size. They are all electric drive, and every plant is equipped with automatic switches that cut various units in and out according to air requirements. Some plants are equipped with both intercoolers and aftercoolers; others depend upon large receiving tanks for aftercooling. Much of the compressor equipment was new, but some was brought in from previous jobs.

All tunnel sections are being driven full face from rail-mounted drill carriages. Conway mucking machines are used on every contract. Muck haul and transportation of materials and supplies in the tunnel is by narrow gage railroad, and all muck must be hoisted up a shaft. Disposal of muck at the surface is by truck, usually to a nearby dump. Muck dumped into the existing reservoirs to fill shallow areas or for diking is treated with hypochlorite of lime solution while on the truck. At other points water draining from the spoil is ditched to a central point and treated with chlorine. For the first time on a large tunnel project automatic feed drifter drills are in use throughout. These include 3½-in. and 4-in. bore machines, with feeds ranging from 24 to 36 in.

Another feature common to all sections is the carrying of high-tension current at 2,300 volts into the tunnel, reducing it to 440, 220 and

110 volts with underground portable transformers. Many of the hoists and larger compressor units on the surface are operated with the 2,300-volt current. The usual electrical arrangement is to carry the high-tension lines from a switchboard at the surface to the tunnel by armored cable placed in conduits buried in the shaft lining. At the bottom of the shaft is another switch, and from here the high tension lines consist of armored cable in 1,000-ft. lengths carried into the heading. Portable transformers mounted on either skids or cars are moved ahead 1,000 ft. at a time as driving progresses. Some contractors step the current down to 440 volts for pump, hoist and mucking machine power and to 110 volts for lighting; others add a 220-volt system for special power requirements. Because so much tunneling equipment is now electric-powered, the contractors feel it well worth-while to carry the high tension lines well into the headings to avoid transmission losses.

#### Drilling and blasting

Naturally the drilling and blasting procedures vary with size of tunnel and type of ground. Typical drilling patterns and shooting diagrams for the three sizes of tunnel are shown in Fig. 3. The number and pattern of holes, and amount of powder used change, however, with different rock formations. The powder factor (lb. of dynamite per cu.yd. excavation) likewise varies from 3.3 in the shales to 6.3 in the harder formations. All contractors use a cut of some kind in the drilling pattern, and some add a baby cut. The cut holes run from 12 to 14 ft. deep, and relievers and lifters from 10 to 11 ft. Advance per round averages from 8.5 to 10.3 ft.

Gelatin dynamites are used in both 40 and 60 per cent strengths. Every known safety precaution is used in handling explosives. Where the shafts are in populated areas, powder is stored in underground magazines driven from the tunnel, otherwise well protected surface magazines are used. All dynamite comes in red paper wrappers to aid in spotting unexploded sticks in the muck pile. Some contractors use conventional primers, with electric detonators inserted in the second or third cartridge from the bottom of the hole. Others use the safety primer developed in the Far West, consisting of a wooden plug containing the detonator, against which is placed a half stick of powder. However, many are now using the recently developed cartons containing the detonator, into which the cartridge making up the primer is slipped. Stemming is required in all holes. A rubber ring and wedge spool plug is common though sand packed in paper bags is used on some jobs.

For safety's sake all power and light lines are removed from the loading zone. On most jobs illumination for loading is supplied by spotlights from batteries on the locomotive. Frazier-Davis uses a special light made up of a motorcycle battery in a box supplying current to a light and reflector on the lid.

The usual blasting hookup is a straight parallel circuit, consisting of two loops of bare No. 14 copper wire hung from dowel plugs. The two leg wires of each detonator are connected to the two bus wires. The bus wires are connected to No. 14 insulated lead wires that go back to the main blasting circuit, which is always carried on the opposite side of the tunnel from the light and power lines. A short distance from the face the blasting line is broken by a switch that is closed by the heading foreman, the last man out before a blast, after he has checked the blasting hookup. At least 1,200 ft. and often 1,500 or 1,800 ft. back of the face is the main blasting switch, which is usually on the 440-volt power line. From this switch a connecting cord is plugged into the blasting switch on the opposite side of the tunnel. First the power is tested by throwing the current through a light circuit, and then the switch is thrown the other way to set off the blast.

All but two contractors are using the conventional forged bits on 1¼-in. round steel, and have the usual forging, sharpening and tempering equipment at each shaft. Two contractors have adopted detachable bits, and both report they are well satisfied with them. These two jobs constitute the largest tunneling operations upon which detachable bits have been used.

Frazier-Davis is using Timken bits in a very hard ground, mostly quartzite. The drills have a 2-ft. feed, and the bit gage starts at 2¼ in. reducing ⅛ in. for each change of steel. The bits are changed on the drill carriage by the driller's helper during drilling operations. Drill bits are sent out to a commercial drill service company for resharpening by the hot mill process. Records show that the number of resharpenings run from an average of 3.32 per bit some months to 5.45 in others. Shanks are made up and threaded on the job. Joint failures average 0.4 per cent; shank failures 3 per cent. This job is effecting an economy in shanks by stand-

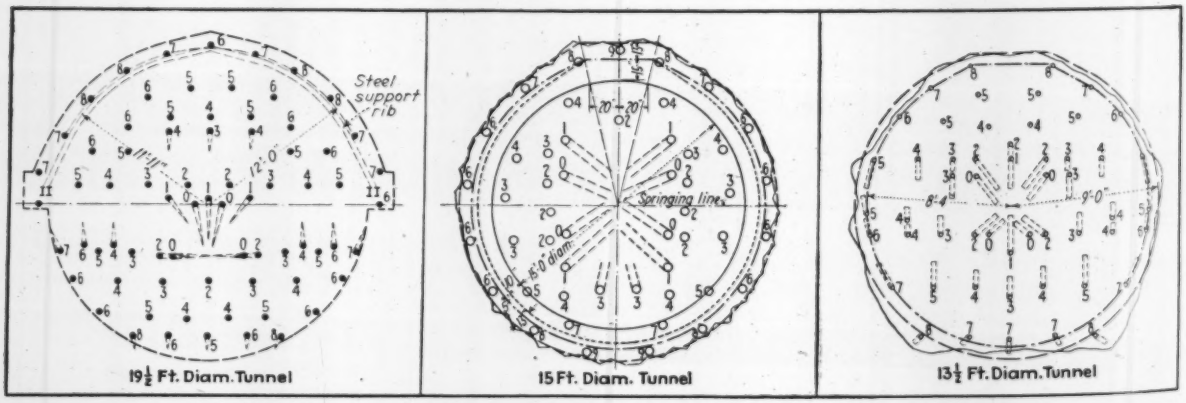



***Fig. 3. Typical drilling patterns on the three different sizes of tunnel. Numbers refer to delays in firing. Left to right: Associated Contractors at Shaft 19; Frazier-Davis at Shaft 10; Walsh at Shaft 5.***

*Fig. 4. Special cars for transporting drill steel between sharpening shop and drill carriage: Top, Seaboard Const. Co. Lower, S. R. Rosoff, Ltd. Car designed to be lowered by the hoist as steel is too long for the cage.*

ardizing on odd foot lengths, 3, 5, 7 ft. etc., at one shaft and even foot lengths at the other. Usually the breaks occur in one end or the other, so nearly every broken shank can be cut down a foot in length for use at the other shaft.

Pleasantville Constructors, Inc., driving through the comparatively soft Hudson River shales, is using Ingersoll-Rand bits of the Pitcher type, instead of the standard cross type. Their drills have 3-ft. feeds, and the starter bits are 2⅛ in., reducing ⅛ in. for each 3-ft. change. All new bits are full size; all smaller gages are resharpened bits. In contrast to Frazier-Davis, Pleasantville resharpens its bits on the job in a hot mill, averaging three resharpenings per bit, 750 bits per shift.

### Drill jumbos and car changers

All contractors use some form of drill carriage or jumbo; some incorporate car changers with the jumbos. Each jumbo carries from six to nine drills, mounted on adjustable bars, columns and arms at the front end. Rosoff, Pleasantville, Dravo, Frazier-Davis and Seaboard operate the jumbos on the narrow-gage muck tracks. Walsh, Utah, Healy and Associated Contractors laid a separate wide-gage track near the face for carrying the drill carriage.

Shea-Kaiser brought in a typical western rig, the King Grasshopper, a combination drill carriage and car passer. This unit, 144 ft. long, runs on 9-ft. 10-in.-gage track of 100-lb. rails and mounts eight or nine drills on the front end. A string of seven empty cars is pulled up a ramp from the rear end onto the upper deck by a hoist and cable for temporary storage. During mucking operations, the empties are run down a movable ramp at the front end one at a time for loading. Loaded cars are pulled back on the muck track. The upper deck and ramps clear the loaded cars and locomotives.

The drill carriages are fitted with a top deck and one or two tiers of side decks which fold for clearance when the jumbo is moved back for the blast. Dravo uses counterweighted wings for safety; Healy utilizes open steel flooring for the decks.

Car changers on the drill carriages are of several types. Healy mounted an air cylinder hoist on an arm at one rear corner of the jumbo as a typical cherry picker that lifts an empty car out of the train and swings it to one side for clearance, while the train is pulled back to place the empty on the front end. Associated Contractors, Utah and Walsh fitted the rear end of the jumbo with a vertical-lift hoist that raises an empty car clear of the train. Seaboard has a novel combination car changer and jumbo. The jumbo is a wide-frame rig that rides on a traveler, similar to a form traveler, operating on the muck track as a drill carriage. During mucking operation, the rig is pulled back a short distance, the overhanging side frame is blocked up from the floor, and the traveler is removed to clear muck trains. The jumbo then operates as a straight cherry picker. Dravo and Frazier-Davis use separate gantry frames as car changers. These are blocked up to clear the train. For moving, swing mounted trucks are brought into position on the muck tracks. The hoists for lifting the empty cars are electrically-operated.

Pleasantville Constructors keep their cars on the ground, but move an empty out of the string to one side by a Mine Door Co. car transfer. This is merely a cross-track upon which runs a low carriage. The carriage can be placed to catch a car, or to clear all cars. The car to be switched is moved over by hand. A pop shot in the side of the tunnel provides a wide enough space for the car to clear the train. Car switching is speeded up by pulling the empty to be loaded, after it is placed back on the muck track at the front end of the train, up to the mucker by a cable and hoist mounted on the rear end of the mucking machine. Rosoff has the simplest car changer, just a multiple-line air hoist hooked to a steel rib of the primary lining, which lifts an empty car clear of the train. Where there is no roof support anchor bolts are placed in holes drilled in the roof.

### Mucking and invert cleanup

Mucking is standardized throughout by the use of 75-hp Conway machines, mostly new but some "built up" from previously used 60-hp models, loading directly into cars. The muckers all operate on a 3-ft.-gage track, except on Healy's two contracts, where the main track gage is 24 in. Here separate mucker rails, 3-ft.-gage, have to be maintained near the face for the mucking machine.

The cars are coupled to the mucker, moving back and forth with the machine as it crowds and loads. Where high-side cars are used, one coupling serves for the full time of loading. With low cars some contractors use a special coupling link that varies the spotting of the discharge end of the conveyor from one end of the car to the other.

Invert clean-up, which can be classified as part of the mucking operations although it is done just prior to placing the concrete lining, is of special interest. Only a few contractors have reached the invert clean-up stage. Healy uses a Sullivan slusher or drag scraper type of mucker for the invert, operating just ahead of the invert concreting. Shea-Kaiser also uses a Sullivan slusher on some headings; on other headings they have converted the King Grasshoppers into drag scraper muckers by adding a 90-ft. boom on one end. The outer end of the boom rests on an A-frame traveling on rails placed at the lower haunches for subsequent concreting of the invert. A hoist on the Grasshopper operates the slack line bucket, which is dragged up the front ramp of the drill carriage for dumping through the deck.

Seaboard has a Sullivan slusher at Shaft 13, but at Shaft 14 is using a Conway mucker converted to a dragline scraper. The mucker hoist operates the cable; the tail sheave is carried by an A-frame on skids. A ½-yd. Sauerman slackline bucket does the cleaning up. Seaboard has supplemented these outfits with an electric-powered tractor and bulldozer. A 25-hp. electric motor replaces the diesel engine on a Caterpillar D4 tractor, which carries a LaPlant-Choate bulldozer with a special moldboard curved to the bottom radius of the tunnel.

Associated Contractors also uses an electric bulldozer, but dispenses with all other scrapers. The bulldozer piles up the invert muck within reach of a Conway loader. Power for the tractor motor is supplied through a cable carried clear of operations by hand. Associated has a rather elaborate final clean-up apparatus in a traveling hood that shields a high-pressure air jet which blasts all loose material from the invert. This jet is supplemented by a combination air-and-water jet that washes the rock clean.

Utah uses a Conway converted to a

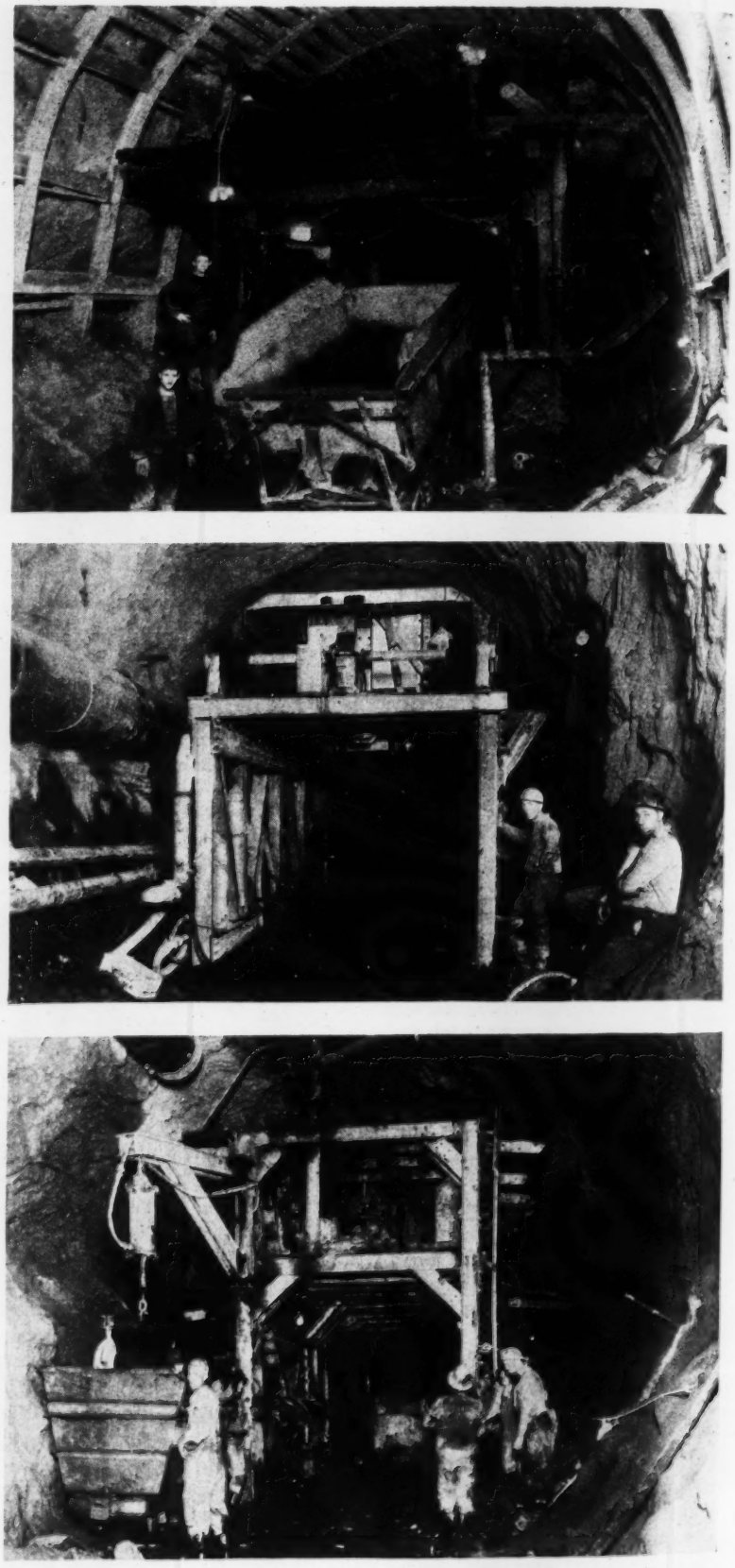


***Fig. 5. Combined car changers and drill carriages. Top, car comes to muck track from storage on upper deck, Shea-Kaiser job. Center, vertical-lift cherry picker, Walsh Const. Co. Bottom, cherry picker on swinging boom, S. A. Healy Co.***

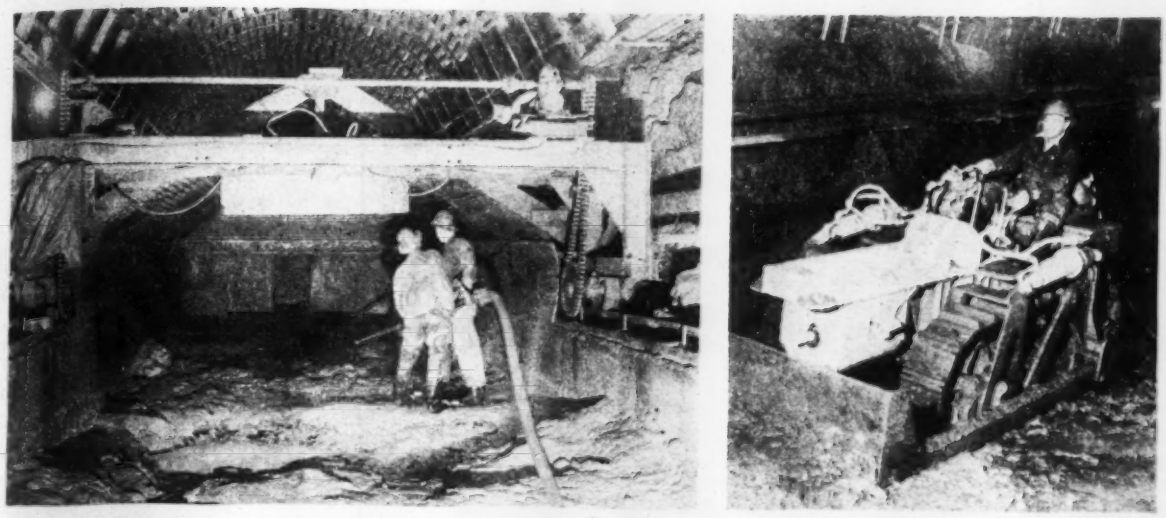


*Fig. 6. Invert clean-up is quite a job. Associated Contractors use a high-pressure air jet under protection of a traveling hood (left) after all muck possible has been scraped up by electric tractor bulldozer.*

slackline cableway by a 45-ft. pipe boom terminating in an A-frame on skids. Seven tail sheave hitches on the A-frame enable the bucket to cover the full width of tunnel. A reversible ¾-yd. bucket is used, which has teeth on one side for digging the muck loose, and a smooth lip on the other side for scraping close to the rock. Pockets are cleaned out by hand. An air and water jet does the final washing, and small sump pumps drain individual pockets.

### Primary ground support

About two-thirds of the entire length of tunnel requires ground support. All support is steel and, in general, consists of two-section ribs resting on wall plates. The ribs form a modified Gothic arch in shape, each half-section being tangent at lower and crown ends and curved in the center. Ribs are 5 or 6-in. H-sections, from 18.9 to 27.5 lb. in weight. They are spaced as needed, but usually at 2, 4 or 6-ft. intervals. At the crown each half-rib carries a butt plate, and the two are bolted together; foot plates of the ribs are either flat plates or short sections of channel iron.

Several types of wall plates are in common use: 6, 8, and 10-in. I-beams, single with web horizontal or vertical, and double with webs vertical; 10 and 12-in. channels, single with web horizontal, or double with webs vertical. Wall plates are carried on blocks to hitches in the walls, or on short timber posts, supplemented, in both cases, by dowels in the side walls.

In some systems channel lagging, either bolted or clipped to the ribs, serve as spreaders; in others light I-beam or channel spreaders are bolted between ribs. Lagging, usually channel sections, is used where required, but occasionally the ribs alone are sufficient. Blocking between ribs and roof is wood studs, generally carried directly on the ribs, held by angle or channel clips.

Supplementing the support, in fact replacing it in some instances, is shotcrete coating of the roof. The cement coating keeps many kinds of ground from raveling and prevents other formations from air slaking and scaling off. The shotcrete is applied in one, two or three layers, each about ½ in. thick. The coating is applied to the sides as well as to the roof, and, on one contract, around the wall posts to keep the hitches upon which they rest from slowly disintegrating.

### Direction

The Delaware Aqueduct is being built by the Board of Water Supply of New York, under the direction of Charles M. Clark, chief engineer, and Roger W. Armstrong, deputy chief engineer in charge of construction. The field work is divided into two departments: Neil Holdredge is in charge of the Northern Department, which includes all tunnels north of Shaft 10, Harry R. Bouten was engineer in charge of the Eastern Department, south of Shaft 10, until his recent promotion to head of the design department when he was replaced by John M. Fitzgerald.

**TUNNEL CONTRACTS, DELAWARE AQUEDUCT**

| Contr. | At Shafts | Tunnel Length, miles | Lined Dia., ft. | Contractor | Value | General Supervision |
|---|---|---|---|---|---|---|
| 313 | 2, 2A, 3 | 14.2 | 13.5 | Samuel R. Rosoff, Ltd. | $18,916,650 | Fred Stiefel |
| 316 | 4, 5 | 9.1 | 13.5 | Walsh Const. Co. | 11,111,111 | Wm. A. Durkin, Richard Byers |
| 318 | 5A, 6 | 6.9 | 13.5 | Pleasantville Constructors, Inc. | 10,697,710 | J. A. Glaeser |
| 319 | 7, 8 | 10.6 | 13.5 | Dravo Corp. | 11,431,975 | R. W. Remp, H. C. Richardson |
| 321 | 9, 10 | 2.3, 4.4 | 13.5, 15.0 | Frazier-Davis Const. Co. | 11,924,450 | Don Blanks, Fred Youmans |
| 322 | 11, 12* | 6.3 | 15.0 | Utah Const. Co. | 10,829,530 | Gus Ayers, Ben Arp |
| 323 | 13, 14* | 5.8 | 15.0 | Seaboard Const. Co. | 10,810,166 | James O'Rourke, James McAtee |
| 324 | 15, 16* | 7.0 | 15.0 | S. A. Healy Co. | 10,985,200 | Merle Miller |
| 306 | 17, 18, 19 | 3.6, 3.0 | 15.0, 19.5 | Associated Contractors, Inc. | 21,333,333 | J. H. Gill, E. H. Hatch |
| 307 | 20, 21 | 5.1 | 19.5 | S. A. Healy Co. | 10,097,135 | Merle Miller |
| 308 | 22, 23, 1A N | 5.5 | 19.5 | J. F. Shea-H. J. Kaiser | 11,971,885 | Tom Price, Ed. Shea |

*Shafts 11 to 16, incl., sunk as part of tunnel contracts; all other shafts sunk under previous contracts.

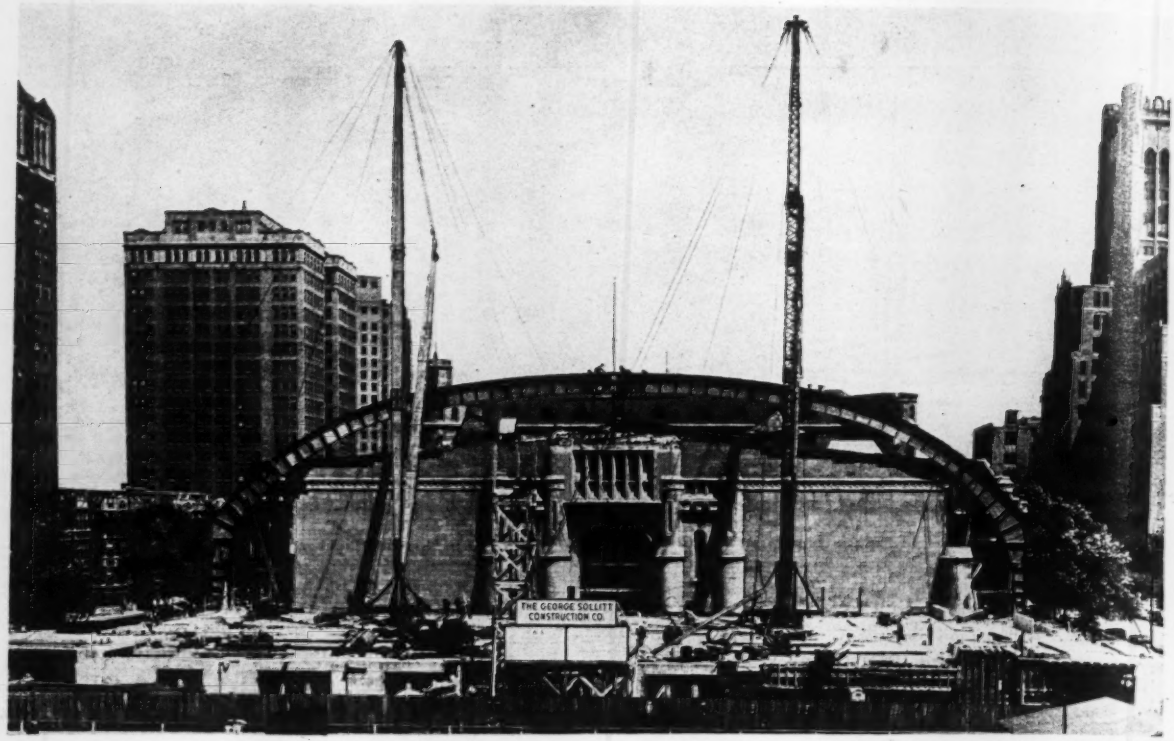



*Fig. 1. Erecting the first roof arch for the armory addition.*

# Enlarging a National Guard Armory

**S. E. Berkenblit**
Consulting Engineer, Chicago

***Contents in Brief**—Part of an extensive armory building program for the Illinois National Guard has been the enlargement, by extension, of an old armory in Chicago. The new construction uses two-hinged arches over the arena and tier framing for the headhouse. Special structural problems were encountered in foundations and frame at junction of old and new buildings. Flat slab floors of several types and a light balcony design are other features of the job.*

FROM A STRUCTURAL STANDPOINT one of the most interesting projects in the program of improving housing facilities for the Illinois National Guard is the enlargement of the old 122nd Field Artillery Armory at Chicago Ave. and Seneca St., in Chicago. Consisting of an extension 119 ft. long and 220 ft. wide, the addition adds about 80 ft. to the length of the first floor arena, provides a 5-story headhouse office building, and enlarges the basement where horse stalls, feed storage, blacksmith shops, etc., can be accommodated. Removal of the end wall of the existing armory above the first floor level joined the old arena to the new extension, giving an arena floor space 125 x 302 ft. A new balcony built around three sides of the enlarged arena joins an existing balcony across the east end of the old armory and provides seats for 4,500 spectators.

Contrast between the old and new construction is striking. Whereas both old and new walls are of limestone, the former include massive pilasters and turrets while the new enclosure is relatively plain. Roof framing in the existing armory consists of 213-ft. Pratt trusses providing 29-ft. clear headroom over the arena, but in the new addition two-hinged rib arches are used to double this clearance. Principal design and construction difficulties occurred at the junction of the old and new buildings. The new floor slabs, the arch ribs, a three-story truss in the backwall of the headhouse and the balcony design are items of interest.

### Foundation

Being located on filled ground, the building is supported by tapered concrete piles (15 ft. average length) driven into an underlying sand stratum. Most of the piles occur in clusters under piers, but under the front wall of the headhouse the foun-

dation is a continuous uniformly loaded beam with piles spaced 2½ ft. on centers and staggered, except at the main door entrance where pier concentrations are taken care of.

At the junction with the old building the existing pile footings in the exterior walls had to carry the extra load of roof and balcony in the remodeled building, and an enlargement of the old footings had to be made. Fig. 2 shows the old pier resting on 7 piles and the method adopted for enlarging this footing to 13 piles. Five of the additional piles were driven outside of the building walls and one pile from inside the building. In order to avoid jetting the latter pile, an opening was cut in the floor slab and a pile driver installed, the high ceiling in the arena making this possible. Grooves were cut in the old pile caps to permit installing girders and connecting beams. After this new framing was thoroughly shimmed against the pier concrete, grout was introduced to effect a bearing on the new piles.

### Floors

Most of the first or arena floor, designed for 125 lb. live load plus a 12-in. earth fill, is of flat slab type 7½ in. thick with dropped panels and column capitals. However, the outside panels of this floor, along the junction line between the old and new building and along the side walls, are designed as 6 in. thick two-way slabs supported on four sides. This type of construction was used because the beams provide the necessary elasticity in supporting the balcony concentrations. By using two-way reinforcement in these slabs to harmonize with the two-way reinforcement in the flat slabs a very efficient combination was worked out, despite the fact that quite different methods of design were required for the two constructions. The uniform thickness of the flat slab was well suited for the encasement of conduit, pipes, etc. Beam and slab type framing was used in the headhouse portion of this floor. So well were the slabs of different type integrated that heavy loads of three times the design capacity, imposed by the contractor on the floor during construction, had no effect on the framing and developed no cracks.

### Roof design

As stated, the roof in the old armory building is carried by trusses; they are about 22 ft. deep at the center and have cambered top and bottom chords. Their 29-ft. headroom was not considered adequate for the new building, which uses three steel rib arches of 213 ft. span and 58-ft. rise. The resulting roof, having a minimum of cross framing and equipped with three lines of flat skylights set in the precast cement tile roofing, provides an abundance of daylight and a striking appearance.

The arches were designed as two-hinged rigid frames, but a third hinge was provided at the crown during erection. The section at the crown of a typical arch consists of a 60 x ½-in. web plate, four 6 x 6 x ½-in. angles, and two 14 x ½-in. cover plates. This section increases to a depth of 84 in. at the haunches and decreases to 22 in. at the 5-in. diameter base pins. A 3¼-in. tie rod connects the arch legs across the building and is encased in the concrete slab of the arena floor. One of the ribs is heavier than the other two because one of its legs had to be carried to basement level to avoid a ramp opening into the basement.

One of the special problems encountered resulted from removal of the end wall of the old armory. Since the ends of the purlins of the old sloping roof were supported by this wall, it could not be removed until the first arch was erected to provide a new support for these purlins. This support was effected by means of hangers suspended from the arch. Since the purlins were shorter than required and of varying length and design as to end bearings, painstaking attention was required in lengthening the purlins, removing the old unsightly bearing details and installing attachments to the new hangers at proper elevation and slope.

In the back wall of the headhouse, directly in front of the balcony seats for the arena, an opening 158 ft. wide by 23½ ft. high is provided by means

***Fig. 2. Detail showing how one of the wall piers was enlarged and increased in capacity to carry extra load.***

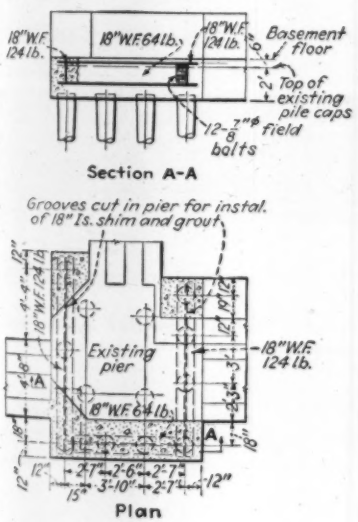
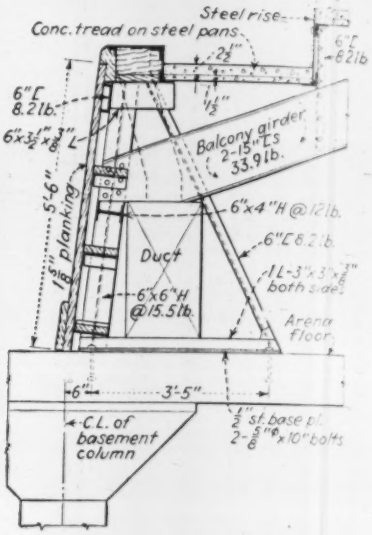


***Fig. 3. Arch framing over the arena extension and tier framing for the headhouse characterize the new extension to the 122nd Field Artillery armory in Chicago.***

**Fig. 4. Light-weight characterizes the balcony by virtue of steel plate risers and concrete treads poured on steel rib decking.**

**Fig. 5. Detail showing kickboard support at front end of balcony girder with brace frame design which affords ample space for ventilation ducts. The balcony girders are supported by short 6-in. H-columns set on the wall at upper end and by larger 6-in. columns set on floor near the center.**




of a three-story truss. This truss, 160 ft. long between supporting columns and 32 ft. deep, is of Baltimore type with sub-verticals and is designed to carry three floors and the roof of the headhouse.

### Balcony

Since no provision had been made for a balcony in the original design of the old building, it was necessary to make it as light as possible. The design finally worked out consisted of sloping girders made of double channels 6 in. back to back, steel plate risers and light weight concrete treads poured on steel rib decking of the type ordinarily used for roofs; by placing the ribs upward a smooth surface resulted beneath the balcony. The balcony girders are supported by short 6 in. H-columns set on the wall at the upper end, by larger 6 in. columns set on the floor near the center and by a kickboard frame at the lower end. This frame (Fig. 5) accomodates ventilating ducts and grilles and is covered with 1⅝ in. planks on the arena side.

### Personnel

The Armory building program is sponsored by the Illinois Armory Board and is financed with the aid of PWA grants. S. Milton Eichberg is architect for the board. For the 122nd Field Artillery Armory, the George Sollit Construction Co. was the general contractor. The Fort Pitt Bridge Works fabricated the steel which was erected by Oscar Daniels Co., Chicago. The writer was consulting engineer on design and construction.

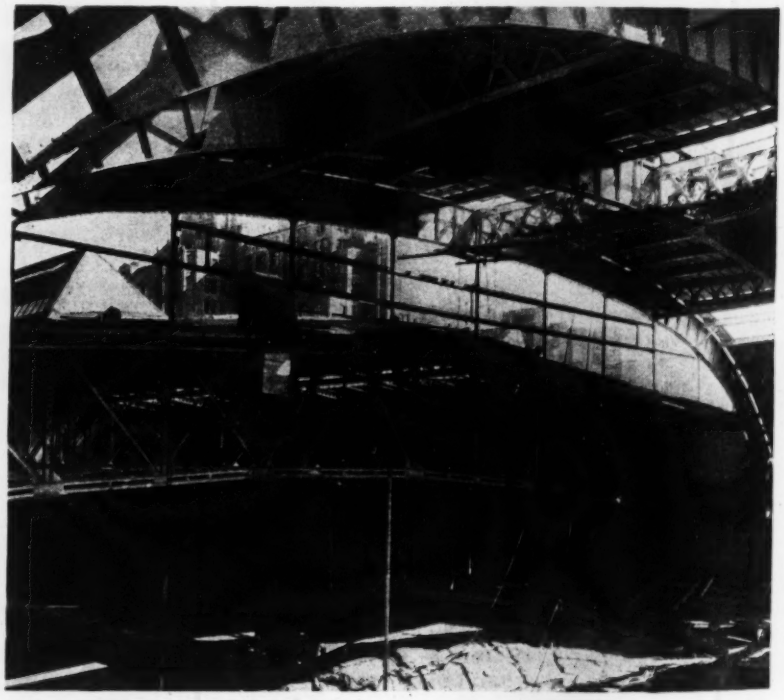


**Fig. 6. At junction of old and new buildings, old roof is supported by hangers from new roof arch. Note balcony at far side of arena.**

*Fig. 1. Upper dam of the Twin Lakes project in the Allegheny National Forest.*

# Recreational Use of Forest Waters

**C. A. Betts**
Engineer, U. S. Forest Service, Washington, D. C.

***Contents in Brief**—Expanding recreational use of the waters in the National Forests has brought new activities to the engineers of the Forest Service in the way of designing dams to improve the recreational advantages of the forest lands. Some of the special types of structures developed for this service are described.*

WITHIN THE PAST DECADE a great increase in use of National Forest lands for recreational purposes has brought new problems to the United States Forest Service. Supervision of the nation's forest lands is no longer limited to timber, wildlife and range management, nor are the Forest Service interests in water restricted to power permits and stock water holes. Forest camps and fishing must be provided on the public lands for the public. Particularly true is this in the Northeast where over one-third of the country's population uses state or national forests as the only remaining unappropriated free camping grounds. In addition to roads to give better access to the forests, dams are needed; dams for fish and game, dams for water supplies, dams for flood control and for water conservation. It is being found that National Forest areas have considerable flood control potentialities at strategic locations near the origin of floods. Local people prefer to have storage reservoirs constructed on unused swamp areas within the forest rather than in the rich populated valleys where some of the best agricultural land would be taken out of taxation for the benefit and protection of communities downstream.

Dams of Region 7 of the U. S. Forest Service (Maine to Kentucky) serve well to illustrate this new phase of forest development. They fall into two general categories: (1) dams constructed in the national forests and (2) dams constructed in state forests under Forest Service technical supervision with government funds. Designs for the former are prepared in the regional office in Washington; plans for the latter are made in the state forest where the project is located or in the state forester's office and submitted to the regional office for approval, with review by the chief engineer's staff if the size warrants.

Earthfill dams with gravity concrete or stone masonry spillways predominate, although masonry dams, concrete arch and timber dams are used where suitable. There are some locations deep in the forests where only log structures are feasible, notwithstanding their life limitations of twenty to forty years. Where possible, the use of local materials is favored.

Dams in remote sections of the forests must be rugged, comparatively inexpensive, and foolproof. For this reason spillways must be supersafe, providing for the once-in-1,000-year floods, unless so situated that no downstream menace is created. The dams built under Forest Service technical supervision in the northeastern states that have been subjected to superfloods twice within two years (March, 1936, and September, 1938) have demonstrated

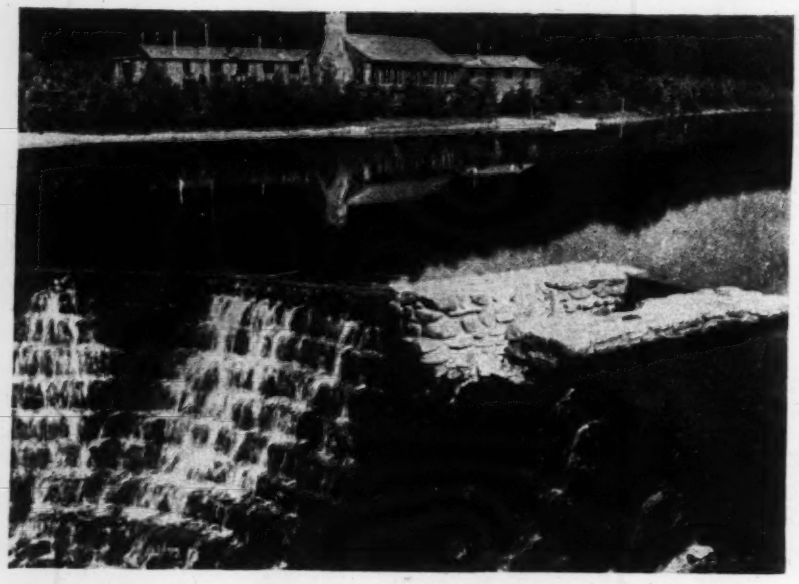


***Fig. 2. Typical of the smaller structures built by the Forest Service is Schreeder Dam in Connecticut. Attractive appearance has been obtained without sacrifice of sound design principles and at little increase in cost over a purely utilitarian structure. Spillways are conservatively designed.***

the soundness of this design policy.

While there is a serious deficiency of hydrologic data concerning runoff from small drainage basins in the United States, studies of forest influences on runoff and measurements of high water in national forests have given some information with the result that runoff curves have been prepared for many of the forests to serve as a guide—where local data are lacking (Fig. 4). The variation between 100 sec.-ft. per square mile flood discharge in the lake region of Maine and 1,000 in the Appalachian Mountains of Virginia is greater than the range between flood peaks for the Rockies and the east or west coasts as a whole. The cloudburst floods of the mountains produce runoff comparable with the high intensity precipitation elsewhere. Provision must be made for both.

A dam to create a lake for wild fowl breeding must have a spillway that can handle flood discharges without causing the lake level to fluctuate more than a foot or so.

The Twin Lakes Dam constructed recently in the Allegheny National Forest in northwestern Pennsylvania to replace an old logging dam in one of the most picturesque and accessible sections of the National Forest is a good example of the dams now being built. It is within a few hours' drive of 80,000 population and recreational use since completion has far exceeded expectations.

Prior to the design of the dam, test pits and borings at the site and in the reservoir area revealed solid hardpan beneath about 12 ft. of gravel, sand and clay strata. Suitable soil for the earthfill of the dam was found close by in the area to be flooded. It contained 7 per cent clay, had an optimum moisture of 15 per cent and dry weight of 118 lb. per cu.ft. The soils mechanics laboratory which was set up on this job not only made daily control tests of soil and concrete here, but also handled the tests for the Beaver Meadows Dam, which was nearby. Where jobs are scattered it has been found advantageous to have portable soil and concrete testing equipment that can be readily transported or operated on a truck. This also applies to wash boring outfits for foundation investigations.

Comparative estimates of the stone masonry type of dam against earthfill with masonry spillway decisively favored the latter when flashboard gates, that would collapse automatically under a predetermined head of water, were used. The automatic flashboard gate 30 ft. wide by 6½ ft. deep provides a capacity of 4,000 cfs. To have provided this without flashboards would have increased the spillway cost about $19,000.

The gate consists of a wooden panel hinged at the spillway floor with massive bronze strap hinges and supported in a vertical position against lake pressure by thirteen 3½-in. galvanized steel pipes set in pipe sockets in the spillway. One-inch pipes, inserted in the top of the 3½-in. pipes by suitable fittings, in turn support the 24-in. upper flashboard gate, which rests on top of the main gate

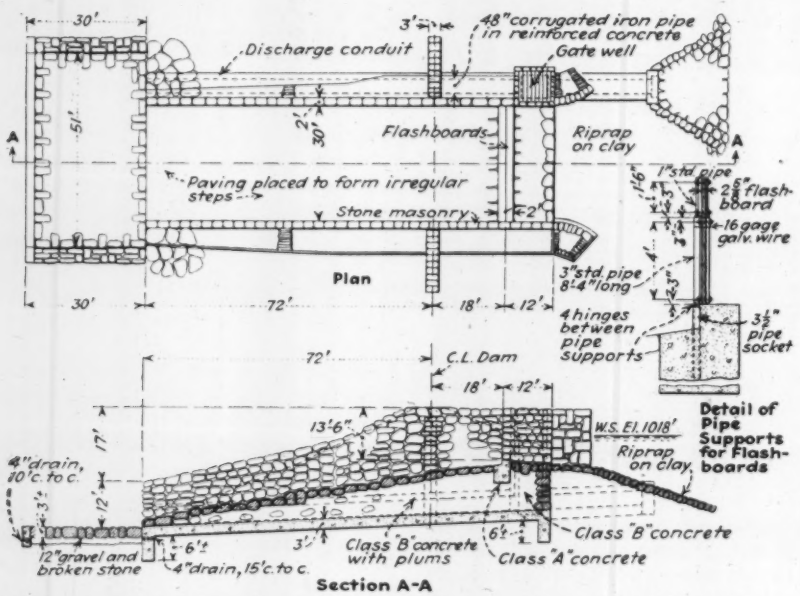



***Fig. 3. Designed to have a rustic appearance, the spillway of the Twin Lake upper dam is a substantial structure carried on a slab of reinforced concrete. Automatic flashboards on the crest are designed to provide for both normal flood flows and abnormal flows.***

and is designed to handle the once-in-five-year floods, while the main gate handles the rare floods.

The picturesque random rubble masonry spillway of this dam carries the 48-in. sluice pipe and valve in the right abutment so that no valve stem projects above the top of the dam. The weight of the masonry spillway is distributed on the foundation by a reinforced concrete mat 3 ft. thick with 6-ft. cutoff. Bearing and permeability tests showed that it would be unnecessary to go down the additional 15 ft. to sandstone. The stream was bypassed through the sluice pipe during construction. The stilling basin is made of large rocks and flanked by landscaping.

Aesthetic treatment of these dams is the inevitable outgrowth of recreational use by a discriminating public. Attractiveness without sacrifice of safety and economy is the objective. Methods of attaining it include the curving of banks at the ends to fit into the topography and the planting of grasses, such as rye, redtop, and blue grass, or vines, such as honeysuckle. Stonework simulates environment in roughness and color, using, as a rule, large stones with raked joints. Concrete can be darkened by the selection of dark aggregates and cement.

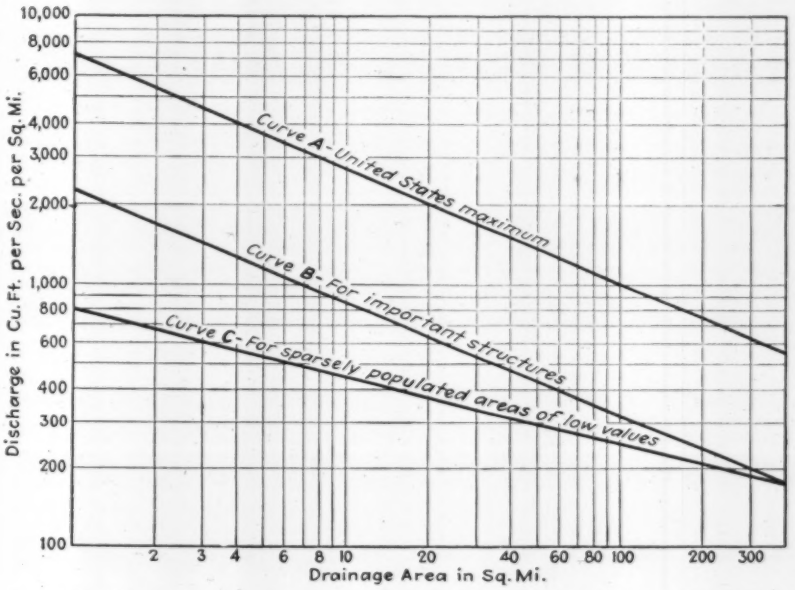



***Fig. 4. Runoff curves for small drainage areas have been constructed by the U. S. Forest Service for use where local runoff data are lacking. This one is for Pennsylvania.***

Economic justification for many of these projects, which contemplate the beneficial utilization of water as well as land resources, has in some cases been predicated on multiple use; a trend more pronounced in public than in private projects. At the present rate of increase of use, it is evident that greater benefits than were originally planned will accrue over the years.

# Water Quality Depreciation in Distribution Systems

WHAT ARE THE CAUSES of bacterial depreciation in distribution systems? Three definite causes were suggested by Norman J. Howard, director of water purification, Toronto, Canada, at the American Water Works Association meeting in Kansas City recently.

They were: (1) Routine treatment of the raw water may not have destroyed bacterial life completely and later the attenuated organisms under favorable water temperature conditions may start multiplying in the distribution system; (2) bacterial life may be present in a dormant condition on the sides of the pipes and may be released as a result of the rising water temperature; and (3) in the absence of sufficient residual chlorine, natural decomposition of dead organisms or organic matter may cause increased bacterial growths in the summer months. Again, in this season there is probably a greater variation in water pressure than normally occurs in other periods of the year, which results in the stirring up of sedimentary deposits within the system.

Assuming that one of the conditions mentioned is among the direct causes of deterioration, will any form of treatment change the picture and are the bacteria of sanitary significance? To the first query one should assume, of course, that current practice is to treat the water adequately before its entry into the distribution system. In heavily polluted surface water excessive sterilization treatment may be necessary to prevent aftergrowths. If superchlorination is employed the destruction of all forms of pathogenic organisms should occur, but secondary decomposition may be more likely to occur unless it is possible to maintain a satisfactory chlorine residual throughout the system. Chloramine treatment following pre- or super-chlorination would seem to be indicated in all heavily polluted waters. In other supplies where superchlorination is either impractical or unnecessary, the use of chloramine treatment should theoretically be successful in preventing bacterial deterioration.

Because there is no seasonal indication of gastroenteritis during the troublesome period involved in many cities, it can be stated with a definite degree of assurance, that such growths in the distribution system do not constitute a health hazard and are of little sanitary significance. It is perhaps unfortunate that depreciation usually occurs during periods of greatest bacterial pollution. It is most improbable, however, that pathogenic types of bacteria present in water, once having been subjected to adequate and intensive sterilization treatment, can later become rejuvenated and be capable of causing waterborne disease. Typhoid fever and gastroenteritis can alone be caused by an infective agent in active form, according to Mr. Howard.

# From Field and Office

**Working problems and time-saving methods for engineers and contractors**

## Coloring Concrete Floors

Contractor Geo. H. Rommel Co. secured excellent results in coloring floors on the Frankfort, Ky., municipal housing project by the following procedure.

Nine pounds of 97 per cent pure iron oxide was mixed with one bag of portland cement, lightly hoed and then sieved twice through a No. 16 mesh screen. Then 125 lb. of sand was added to the mixture of cement and coloring matter and this was lightly hoed and sieved twice through the No. 16 mesh screen. The mix was rebagged, each batch being kept separate until needed, when it was spread on the fresh concrete as soon as the slab was screeded. Spreading was done with a mason's sieve and the area to be covered by each batch was measured off on the slab so each batch covered approximately 117 sq. ft. of floor. This provided a $\frac{1}{8}$-in.-thick top, which troweled to a good finish.

As soon as the topping was placed the finishers floated it, working the topping well into the slab, then leveled it by straightedging, after which it was troweled to a polish with a steel trowel, producing a dense, hard, smooth surface of even color.—IRA A. BUTCHER, *Lexington, Ky.*

## Concrete Mixer Plates

In rebuilding two 4-cu. yd. concrete mixers for use at Friant Dam, the interior arrangement was changed to consist of simply three manganese steel plates, equally spaced around the circumference and in planes radial to the axis of rotation.

A departure from standard design in these plates is the use of more thickness along the exposed edges to provide more metal where the wear is heaviest. The accompanying view shows the thickened edges of several plates lying on the mixer plant deck awaiting assembly in the mixers.

## Lighthouse on Skids

A wooden frame on skids carries two floodlights powered by an 800-watt plant in the "shanty." This rig was used by John H. Swanger of Lancaster, Pa., for night paving on the Pennsylvania Turnpike.

## City Garbage Cans

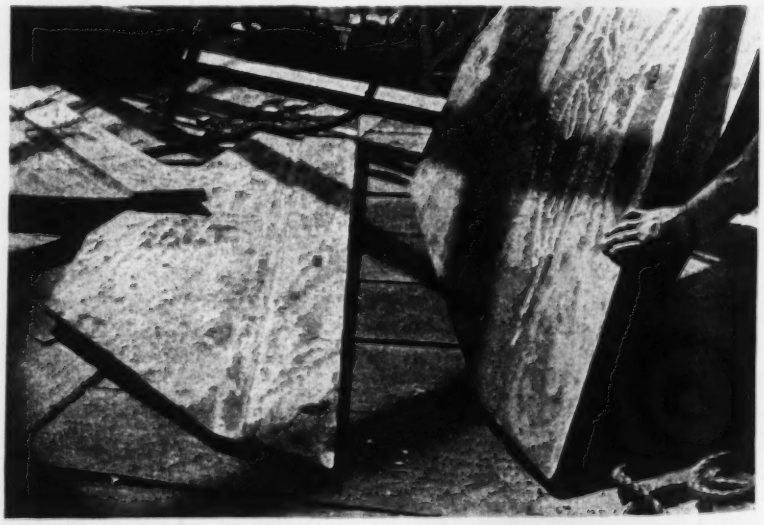
The city of Lansing, Mich., furnishes the householders with a clean garbage can at every collection (*ENR* June 2, 1938). The loading, hauling, dumping and cleaning means a multitude of handling operations which requires sturdy construction. Recently purchased 10-gal. cans are hot dipped galvanized corrugated sheet steel built to the following specifications:

Top diam., Inside, 14 in.
Bottom diam., Outside, 12$\frac{1}{2}$ in.
Depth, Inside, 14$\frac{1}{2}$ in.
Top band, 20-gage corrugated
Body, 23-gage corrugated
Bottom, 22-gage ring corrugated
Bottom band, $\frac{3}{4}$ in. x 1 in. with 6 rivets
Top is rolled over $\frac{1}{4}$-in. steel wire
Handles, $\frac{5}{16}$ in. round, 3$\frac{1}{2}$ in. from top
Covers, 24-gage 2-in. flare.

Only $\frac{1}{8}$-in. tolerance is allowed in the top size but the covers are made $\frac{1}{2}$-in. diam. larger than the top of the can. S. C. Jacka, city engineer, recommends holes through the bottom ring as desirable to release the trapped water when the cans leave the washer bottom up to drain the interior. With the present design the attendant must dump the water on the floor before stacking the cans.

*Lighthouse for night paving.*

*Lansing's new garbage can.*



*Thickened-edge manganese steel plates for Friant Dam mixers.*

# Book Notes and Reviews

**The month's addition to the engineer's reading and reference list**

### Handbook Revised

CIVIL ENGINEERING HANDBOOK — Second Edition. Leonard Church Urquhart, editor-in-chief. 877 pp. Published by McGraw-Hill Book Co., New York and London. Price $5.

Six years have elapsed since this handbook first made its appearance and in that six years many developments have come about that would affect the contents of a handbook for civil engineers. In most of the sections of this book these changes have been recognized in the revision. They do not appear in what was one of the best sections of the first edition, the section in foundations.

None of the major deficiencies of the first edition have been made up in revision. The book still lacks anything on tunnel construction, navigation canals and locks, wharves, water power, cantilever and suspension bridges, viaducts and trestles. It contains little of value on the subject of dam design or construction.

### For Sanitary Engineers

SEWAGE TREATMENT—By Karl Imhoff and Gordon M. Fair. 370 pp. Published by John Wiley & Sons, New York, and Chapman & Hall, London. Price $3.

Presenting "briefly and simply the considerations and calculations that enter into the design and operation of modern sewage treatment plants", this book by Messrs. Imhoff and Fair also provides a critical evaluation of present practice which should be of special interest to sanitary engineers. Both authors are active participants in, and thoughtful observers of developments in sewage disposal, and consequently their interpretation of process application and design has much practical value.

Coupled with the 14 chapters discussing standard treatment methods, are five chapters dealing respectively with water-carried wastes from unsewered habitations and industrial establishments, industrial waste treatment, self-purification of streams, disposal by dilution and sample calculations in design problems. The section on the origin and treatment of common industrial wastes has been written by Prof. Edward W. Moore of the Harvard Graduate School of Engineering.

In the chapter on self-purification of streams there is illustrated a graphical method for determining the dissolved oxygen profile, the use of which eliminates tedious mathematical calculation. Throughout the book there are many valuable tabular summaries of chemical costs, process efficiencies, sludge characteristics and other matters on which comparable data is frequently needed.

### An Aid to Contractors

CONSTRUCTION PLANNING AND PLANT—By Adolph J. Ackerman and Charles H. Locher. 381 pp. Published by McGraw-Hill Book Co., New York and London. Price $4.

Written by two practical men, this book fills a large gap in literature designed to aid the construction industry. Proper planning of the construction operations of a big job and knowledge of what equipment to use are prime essentials to successful construction, and yet textbooks on these subjects are almost unknown. This is due chiefly to the fact that the men who know most about these subjects —the practical construction men— don't like to write.

A. J. Ackerman, the principal author of this book, is an exception to that rule. Drawing on the unusually broad knowledge of construction equipment that he gained in his service with the Aluminum Company of America, the federal government and the TVA, he laid the foundation for this book in a series of articles for *Construction Methods*. In the preparation of those articles he had the advice of Charles H. Locher, a contractor of wide experience.

The book covers preliminary planning and essentials to the start of work such as camp and shops, plant layout and scheduling, and selection of equipment. Each major type of construction equipment is made the subject of a separate chapter. In addition there are chapters on cofferdams and river diversion, foundation consolidation, cutoffs and caissons, and on human relations.

The book centers around dam construction and river work but contains much that will be useful on other types of heavy construction.

### Two Books on Transport

THE ECONOMICS OF TRANSPORTATION IN AMERICA—By Kent T. Healy. 575 pp. Published by The Ronald Press Co., 15 East 26th St., New York City. Price $4.

TRANSPORTATION — Economic Principles and Practices — By Emory R. Johnson, Grover G. Huebner and G. Lloyd Wilson. 678 pp. Published by the D. Appleton-Century Co., New York and London. Price $4.

Professor Healy of Yale and Professors Johnson, Huebner and Wilson of Princeton have done a real service to students of transport by writing the two books reviewed here. The two volumes are in a large measure complementary. Both cover all types of transport, but while Prof. Healy centers attention on the economic forces affecting development over the years, the teachers from Princeton stress the processes and business of transportation as it has grown from early beginnings. The books can well be read together, by older readers as reminders of striking events witnessed, and by younger ones as a source book of dates and events in an industry that has revolutionized world economics.

As a successor to "Principles of Transportation" by the same authors, "Transportation" goes far beyond any definition of revision. It is a new book. Essentially it is a treatise on the processes and business methods of transportation by rail, water, air, highway and pipeline. Economic practices rather than economic forces and motives are considered. Obviously no book of 700 pages can provide a working manual for transportation officials; it can, however, and this book does give a review of current practices widely informative to the student and general reader. Supplementary reading on each subject is listed at every chapter end and there is an excellent contents index.

The ambitious purpose of the author of "The Economics of Transportation in America" to analyze the

long and complex history of transportation economics in one book commands respect. He has made this task possible by unusual condensation and wise restraint from excursions into borderland developments in the mechanics and business procedures of transportation. The discussion is not mere statement of facts; it is statement enlightened by explanation of the economic forces and motives behind the facts. The student of transportation has been done a signal service by Prof. Healy.

### Government Policies

GOVERNMENT AND ECONOMIC LIFE, Vol. II—By L. S. Lyon, Victor Abramson and associates. 1,301 pp. Published by The Brookings Institution, 722 Jackson Place, Washington, D. C. Price $3.50.

This second volume of "Government and Economic Life" relates to the effect of government regulatory policies upon some of the larger elements of our economic system. For engineers, the sections on public utilities and transportation will be found to give a terse summary of what the lack of definite governmental policies has done in those two fields. There also is a chapter on public relief in which such matters as employment conditions on work relief projects are discussed.

### Independent Unions

INDEPENDENT LABOR ORGANIZATIONS and the National Labor Relations Act—By Frank T. Bow. 120 pp. Published by Prentice Hall, Inc., New York. Price, $2.

This book is addressed to the small groups in industry who for one reason or another are disinclined to throw in their lot with other organized groups and who yet are beginning to realize that they might be more secure in some sort of a labor organization, even if only to be kept from being gobbled up by a large union having little interest in their peculiar problems. Engineers in some of the larger industrial organizations fall into this class.

Mr. Bow lays emphasis on the fact that the National Labor Relations Act gives to such small groups as engineers in large industrial corporations the right to set up their own independent organization to bargain collectively with their employer. Under the act they are entitled to claim and receive recognition as a collective bargaining group if they represent the majority of the men doing their particular type of work. They may or may not affiliate with some outside organization, just as they desire.

### Pollution Survey Methods

SEWAGE POLLUTION: Chemical and Bacteriological Studies of the Interstate Sanitation District—Works Projects Administration report for the city of New York, sponsored by the Interstate Sanitation Commission, 60 Hudson St., New York. 300 pp. Limited free distribution.

Practical information on the methods and equipment employed in conducting pollution studies in natural waterways is contained in this WPA report of conditions in the Interstate Sanitation District (New York and New Jersey). In addition, the report includes complete data on present chemical and bacteriological characteristics of the waters in New York harbor and contiguous areas.

Details are given concerning the tests used, sampling technique and laboratory method of analyses. Of special interest is the description of a new method of computing oxygen solubility values based on temperature and sea water density relationships. Chester G. Wigley, engineer in charge of the project study, and Seth G. Hess, chief engineer of the Interstate Sanitation Commission, under whose sponsorship the work was done, have compiled valuable data on pollution studies in this report.

## Miscellaneous Notes on Booklets and Reprints

A BRIEF SUMMARY of "Public Aid to Transportation", (*ENR*, May 23, page 743) has been published by the National Highway Users Conference, National Press Bldg., Washington, D. C., under the title "Highway Users Pay Their Way and More".

A BIBLIOGRAPHY of traffic safety books and pamphlets has been prepared by the Department of Public Relations, General Motors Corp., New York, in cooperation with a number of organizations such as the American Association of State Highway Officials. The pamphlet gives the titles of the books and papers, their source and price.

MOSQUITO CONTROL IN NEW YORK CITY, a report of what is done and how, has been prepared for distribution by the Department of Sanitation. Copies may be obtained by addressing A. J. Lizee, deputy commissioner, 125 Worth St., New York.

DESIGN SPECIFICATIONS for Bridges and Structures of Alminum Alloy 27 S-T, practically paralleling the A.R.E.A. specifications for steel railway bridges, are published in pamphlet form by the Aluminum Company of America, Pittsburgh, Pa. They were prepared by Leon S. Moisseiff, consulting engineer, New York, and have been revised for 1940.

A SUBJECT INDEX of the library of reports published by the National Resources Planning Board (and its predecessors, National Planning Board, National Resources Board and National Resources Committee) has just been published by the board. Prepared by a WPA staff directed by G. H. Nyberg, it provides a precise and detailed guide to the many discussions of natural resources, planning procedure, economics and the like issued by the board since its creation seven years ago.

A STUDY OF MEANS OF PREVENTING FLOODS along the upper course of the Milwaukee River is presented by the Wisconsin State Planning Board in a special report to the governor just issued in mimeograph form. As the river flows on the bedrock surface for most of its course it has steep gradient and many grade breaks. Numerous low areas along its banks, exposed to high water, have been occupied for residential use and are flooded under extreme conditions. Detention storage and flood diversion into Lake Michigan are possible.

RECENT ADDITIONS to the pamphlet entitled "Building Materials and Structures" published by the National Bureau of Standards include the following: Surface Treatment of Steel Prior to Painting; Air

*(Continued on p. 70)*

# New— FASTER WAY OF EARTHMOVING..

MADE IN THREE SIZES, *with capacities ranging from 11 to 45 heaped yards. Illustration shows Model C Tournapull with LS (11 heaped yards) Carryall Scraper.*

# THE TOURNAPULL METHOD

## TAKES UP WHERE TRACTORS LEAVE OFF... EXTENDS LeTOURNEAU CARRYALL SAVINGS TO LONG HAULS

Tournapulls . . . newest thing in earthmoving . . . are designed to give you one-man earthmoving on long hauls. They combine in one fast-moving, self-propelled unit all the advantages of the job-proved LeTourneau Carryall Scraper and the world famous "Caterpillar" Diesel engine. They utilize the LeTourneau self-loading feature, which with a pusher eliminates the need for special loading equipment and cuts out waiting at the shovel. They haul tractor-size loads at truck speeds and spread their own loads, thus save you the need for spreading tools at the fill. No other equipment now on the market can deliver so much yardage so fast or so cheaply.

EASY, SAFE, SIMPLE TO OPERATE—*Same positive, quick-acting Power Control Unit that makes Carryall loading and spreading so simple with Tractors is used on Tournapulls. Shifting and steering differ but little from tractor operation.*

HAULS AT TRUCK SPEEDS—*Model C Tournapull speeding 11 heaped yards to the fill at 14 m.p.h. This Tournapull is one of four now working on a highway job in Upper Michigan on hauls of one-half to three miles one way.*

See for yourself what Tournapulls can do. Ask your LeTourneau dealer to show you how they extend Carryall savings to long hauls. See him NOW to assure yourself early delivery.

# LETOURNEAU

PEORIA, ILLINOIS • STOCKTON, CALIFORNIA

*For Lowest Net Cost per Yard* - CARRYALL* SCRAPERS, ANGLEDOZERS*, CRANES, BULLDOZERS, POWER CONTROL UNITS, DRAG SCRAPERS, PUSHDOZERS, SHEEP'S FOOT ROLLERS, ROOTERS*, TREEDOZERS, TOURNAPULLS*, TOURNATRAILERS* *Name Reg. U. S. Pat. Off.

# CONTRACT UNIT PRICES

***What contractors are bidding on different kinds of construction work***

## HIGHWAYS, CONNECTICUT

OWNER: Connecticut State Highway Department, Hartford; Wm. J. Cox, highway commissioner.

PROJECT: Construction of Hartford-Windsor Road, Route US 5A, from Main St., Hartford at the city line, north to "Green" at Windsor Center. Project is of reinforced concrete, four lane construction. Two roadways each 24-ft. wide separated by 5-ft. park area raised 5-in. and surfaced with 2-in. bituminous macadam. Graded for 4-ft. walk area outside of roadways. Length is 18,878-ft. Reinforced concrete 8-in. thick.

CONDITIONS: About 4,570 feet of road is in new location, balance is through closely built-up sections where cross-section takes nearly entire width between highway lines. Cement is to be billed to contractor at the price named in bid, $2.20 per bbl. Contractor to furnish all materials for work except cement, and finish job in 350 calendar days. Rail and highway transportation facilities available. Wage rates specified are: skilled labor, 75c. to $1.50 per hr.; semi-skilled, 60 to 75c.; and common, 50c. per hr.

BIDS: Nine bids were received July 22, 1940, ranging from the contract low of $467,000 to $552,357.

LIST OF BIDDERS:

1. New Haven Road Constr. Co., New Haven, Conn. (contract) ..... $467,000
2. D. V. Frione & Co., New Haven, Conn. ..... 473,659
3. N. D. Maselli Corp., Bloomfield, Conn. ..... 486,682
4. The Lane Constr. Corp., Meriden, Conn. ..... 487,220
5. M. A. Gammino Constr. Co., Providence, R. I. ..... 503,929
6. The Osborn-Barnes Co., Danbury, Conn. ..... 507,450
7. A. I. Savin Constr. Co., East Hartford, Conn. ..... 509,611
8. Mariani Constr. Co., New Haven, Conn. ..... 533,709
9. Patterson & Rossi, Inc., Torrington, Conn. ..... 552,357

| Item | Quan. | Unit Prices (1) | (2) | (3) |
|---|---|---|---|---|
| 1. Clear and grub | L.S. | $15,000.00 | $15,700.00 | $14,000.00 |
| 2. Unclassified excavation | 119,479 c. y. | .25 | .30 | .20 |
| 3. Trench excav., to 6 ft. | 11,300 c. y. | 1.25 | 1.25 | 1.25 |
| 4. Trench excav., 6 to 10 ft. | 3,600 c. y. | 1.25 | 1.50 | 1.50 |
| 5. Trench excav., over 10 ft. | 280 c. y. | 2.50 | 2.00 | 1.75 |
| 6. Formation of subgrade | 117,265 s. y. | .10 | .10 | .10 |
| 7. Shape slopes and shoulders | 18,879 l. f. | .15 | .15 | .15 |
| 8. Bridge excavation | 2,239 c. y. | 2.00 | 1.25 | 1.50 |
| 9. Gravel fill sub-base | 39,772 c. y. | .475 | .60 | .60 |
| 10. Broken stone (for base) | 1,412 tons | 1.85 | 1.40 | 1.50 |
| 11. Concrete base course | 161 c. y. | 4.00 | 4.25 | 4.50 |
| 12. Fabric expand. metal or bar mat reinf. for conc. base crse. | 965 s. y. | .20 | .22 | .23 |
| 13. Concrete pavement | 25,010 c. y. | 4.00 | 4.00 | 4.50 |
| 14. Fabr. exp. met. or bar mat for conc. pavement | 112,108 s. y. | .22 | .22 | .23 |
| 15. Transverse expansion joints | 13,361 l. f. | .65 | .65 | .70 |
| 16. ½-in. premoulded exp. joint | 2,000 l. f. | .06 | .05 | .30 |
| 17. ½-in. prem. cork exp. joint | 310 l. f. | .10 | .30 | .30 |
| 18. Broken stone (bit. mac. surf.) | 840 ton | 2.00 | 1.65 | 1.50 |
| 19. Furn., apply bit. mat'l, asph. for penetration | 13,383 gal. | .10 | .10 | .10 |
| 20. Class A concrete | 1,006 c. y. | 14.00 | 13.50 | 1.400 |
| 21. Class B concrete | 810 c. y. | 12.00 | 10.60 | 12.50 |
| 22. Class D concrete | 95 c. y. | 20.00 | 25.00 | 20.00 |
| 23. ¼-in. cork or rubber exp. jt. filler | 330 s. f. | .40 | .30 | .60 |
| 24. Deformed steel bars | 157,570 lb. | .04 | .04 | .04 |
| 25. Dry rubble masonry | 35 c. y. | 8.00 | 9.00 | 10.00 |
| 26. Std. catch basins | 9 ea. | 55.00 | 50.00 | 60.00 |
| 27. Curb type catch basins | 126 ea. | 65.00 | 70.00 | 70.00 |
| 28. Special catch basins | 80 ea. | 50.00 | 40.00 | 85.00 |
| 29. Spec. type A catch basins | 5 ea. | 85.00 | 25.00 | 100.00 |
| 30. Manholes | 83 ea. | 70.00 | 70.00 | 70.00 |
| 31. Manholes over 10-ft. deep | 1 ea. | 100.00 | 100.00 | 100.00 |
| 32. 15-in. rein. conc. pipe | 5,780 l. f. | 1.40 | 1.32 | 1.30 |
| 33. 18-in. rein. conc. pipe | 8,600 l. f. | 2.00 | 1.75 | 1.80 |
| 34. 24-in. rein. conc. pipe | 2,900 l. f. | 3.00 | 2.55 | 2.60 |
| 35. 36-in. rein. conc. pipe | 124 l. f. | 6.00 | 4.90 | 4.00 |
| 36. 42-in. rein. conc. pipe | 588 l. f. | 8.00 | 6.50 | 6.50 |
| 37. 48-in. rein. conc. pipe | 84 l. f. | 10.00 | 8.00 | 9.00 |
| 38. 8-in. tile pipe | 220 l. f. | .80 | .50 | 1.00 |
| 39. 8-in. tile wyes | 3 ea. | 5.00 | 1.00 | 3.00 |
| 40. Relay 6-in. tile pipe | 20 l. f. | .50 | .50 | 1.00 |
| 41. Relay 48-in. rein. conc. pipe | 24 l. f. | 4.00 | 4.00 | 3.00 |
| 42. Timber piles, 30-ft. lengths | 3,540 l. f. | .40 | .60 | .30 |
| 43. Driving timber piles | 3,540 l. f. | .20 | .20 | .30 |
| 44. Loading test piles | 2 ea. | 10.00 | 50.00 | 10.00 |
| 45. Furn. equip. for driv. test piles | L.S. | 10.00 | 50.00 | 10.00 |
| 46. Slope paving | 120 s. y. | 3.00 | 2.00 | 3.00 |
| 47. Riprap | 152 ton | 1.50 | 1.50 | 1.50 |
| 48. Waterproof painting | 533 s. y. | .30 | .35 | .50 |
| 49. Fndn. underdrain with 6-in. perf. bit. coat. corr. met. pipe | 710 l. f. | 1.00 | 1.00 | 1.25 |
| 50. Doweled conc. curb | 34,699 l. f. | .18 | .25 | .20 |
| 51. Spec. doweled conc. curb | 168 l. f. | .50 | .50 | .70 |
| 52. Plain conc. curb | 2,633 l. f. | .75 | .50 | .70 |
| 53. Spec. conc. curbing | 75 l. f. | 1.00 | 1.00 | .70 |
| 54. Conc. bridge rail | 116.5 l. f. | 5.00 | 6.00 | 7.00 |
| 55. Wire fence | 6,871 l. f. | .17 | .22 | .20 |
| 56. Reset wire fence | 138 l. f. | .17 | .15 | .20 |
| 57. Wire rope railings | 6,000 l. f. | .40 | .35 | .40 |
| 58. Type B anchorages | 6 ea. | 8.00 | 15.00 | 10.00 |
| 59. Single posts | 40 ea. | 1.25 | 1.75 | 1.50 |
| 60. Posts for reset and repainted wire rope railing | 25 ea. | 1.25 | 1.50 | 1.00 |
| 61. Temporary bridge | L.S. | 500.00 | 300.00 | 1,000.00 |
| 62. Remove old superstructure | L.S. | 400.00 | 50.00 | 1,000.00 |
| 63. Reset and repainted wire rope railing | 830 l. f. | .25 | .25 | .30 |
| 64. Type C anchorages | 10 ea. | 8.00 | 7.00 | 10.00 |
| 65. Compensating type anchorages | 40 ea. | 8.00 | 10.00 | 10.00 |
| 66. Barways | 10 ea. | 10.00 | 8.00 | 10.00 |
| 67. Service bridges | 155 ea. | 15.00 | 15.00 | 10.00 |
| 68. Loose gravel surface | 280 c. y. | 1.00 | 1.00 | .60 |
| 69. Loose broken stone surface | 275 c. y. | 2.00 | 1.75 | 1.75 |
| 70. Portland cement | 40,513 bbl. | 2.20 | 2.15 | 2.20 |
| 71. Concrete sidewalk | 42,400 s. f. | .20 | .18 | .20 |
| 72. Gravel walk (surface treat.) | 2,500 s. y. | .20 | .40 | .35 |
| 73. Relay brick walk | 240 s. f. | .10 | .20 | .25 |
| 74. Relay flag walk | 30 s. f. | .10 | .20 | .25 |
| 75. 2-in. galv. w. i. pipe railing | 25 l. f. | 1.00 | 2.75 | 1.00 |
| 76. Concrete ramps | 4,500 s. f. | .25 | .25 | .25 |
| 77. Spec. galv. w. i. pipe rail., 2-in. | 310 l. f. | 1.00 | 2.75 | .60 |
| 78. Bitum. conc. surface | 9,178 s. y. | .85 | .80 | 1.00 |
| 79. Junction box | L.S. | 100.00 | 70.00 | 100.00 |
| 80. Broken stone, bridge drains | 91 tons | 1.50 | 2.00 | 1.50 |
| 81. Metal flashing | 104 lb. | .50 | .50 | 1.00 |
| 82. Paved ditches | 20 s. y. | 2.00 | 2.00 | 1.00 |
| 83. Reset wood picket fence | 207 l. f. | .50 | .50 | 1.00 |
| 84. Temporary wire fence | 5,915 l. f. | .10 | .15 | .15 |
| 85. Furn. and place calcium chloride | 85 ton | 20.00 | 35.00 | 40.00 |
| 86. Maintenance of traffic | L.S. | 1,511.84 | 3,000.00 | 5,000.00 |
| 87. Gravel base for gutters | 165 c. y. | 1.00 | 1.00 | 1.00 |

## BULKHEAD AND SLIP CLEVELAND, OHIO

OWNER: City of Cleveland, C. B. Patterson, purchasing agent; G. B. Sowers, engineer.

PROJECT: Construction of bulkhead and fire tug slip, Cuts 9-6 and 5-A, in connection with Cuyahoga River improvement, Cleveland, Ohio. (Contract 21)

CONDITIONS: Contractor to furnish all materials. Water and highway transportation facilities available. Wage rates specified are: hoisting engineers, $1.37½ per hr.; structural ironworkers, $1.62½; semi-skilled workers and common labor, 90c. per hr.

LIST OF BIDDERS:

BIDS: Three bids were received April 18, 1940, ranging from the contract low of $70,236 to $87,324.

1. Great Lakes Dredge & Dock Co., Cleveland, Ohio (contract) ..... $70,236
2. L. A. Wells Constr. Co., Cleveland, Ohio ..... 82,749
3. Merritt-Chapman & Scott Corp., New York, N. Y. ..... 87,324

| Item | Quan. | Unit Prices (1) | (2) | (3) |
|---|---|---|---|---|
| 1. Clearing site, Cut 9-6 | L. S. | $3,200.00 | $5,111.00 | $11,400.00 |
| 2. Sheet steel piling, front row (9-6) | 490 ton | 65.00 | 77.00 | 75.00 |
| 3. Sheet steel piling, anchorage row (9-6) | 70 ton | 85.00 | 82.50 | 100.00 |
| 4. Misc. steel and bolts (9-6) | 102,000 lb. | .06 | .08 | .075 |
| 5. Anchor rods (9-6) | 90,000 lb. | .10 | .055 | .06 |
| 6. Timber waler (9-6) | 14 Mbm | 105.00 | 145.00 | 120.00 |
| 7. Bulkhead guard rail, Cut 5-A | 52 l. f. | 4.25 | 5.08 | 5.00 |
| 8. Sheet steel piling, front row, (5-A) | 85 ton | 70.00 | 80.00 | 85.00 |
| 9. Sheet steel piling, anchorage row, (5-A) | 10 ton | 70.00 | 80.00 | 75.00 |
| 10. Misc. steel and bolts, (5-A) | 28,000 lb. | .06 | .06 | .065 |
| 11. Anchor rods, Cut 5-A | 3,000 lb. | .10 | .065 | .065 |
| 12. Timber waler at Cut 5-A | 6 Mbm | 105.00 | 145.00 | 150.00 |
| 13. Excavation, Cut 5-A | 2,250 c. y. | .50 | 1.00 | .50 |
| 14. Concrete, Cut 5-A | 12 c. y. | 20.00 | 15.00 | 15.00 |
| 15. Clear site, Cut 5-A | L. S. | 1,800.00 | 5,710.33 | 4,360.00 |